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Electrical

SUPPLEMENT TO "THE ELECTRICAL ENGINEER," JUNE 24, 1892.

THE

ELECTRICAL ENGINEER.

A WEEKLY JOURNAL OF ELECTRICAL ENGINEERING,

WITH WHICH IS INCORPORATED

"ELECTRIC LIGHT."

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NOTE.—General Articles, Correspondence, and Companies' Meetings are indicated by heavier type (thus, 290) than the Notes, references to which are shown by light type (thus, 290).

THE

ELECTRICAL ENGINEER.

No. 1, Vol. IX. LONDON, JANUARY 1, 1892. PRICE 3D.

NOTES.

Crystal Palace Exhibition.—The opening of the Electrical Exhibition, which was fixed for January 1, has been put off until January 9.

Marennes.—The town of Marennes, France, has made the jump from oil to electricity without passing through the intermediate stage of gas.

Paris Lighting.—The Continental Edison Company's gross receipts for electric lighting during the month of November, 1891, amounted to 245,613f.

Unicycle Electric Road.—It is said that Chicago is to have an electric unicycle railroad, to run from Lake-street to Jackson Park, on which the cars are to run at the rate of 40 miles an hour.

Aberdeen Tramways.—A movement is on foot at Aberdeen to extend the tramway to the Links, and the sea beach. The electric traction engineers should put in a word as to their systems.

Factory in Paris.—A factory for manufacture of indiarubber is to be sold by tender in Paris, January 3rd. Apply M. Navarre, 61, rue des Petits-Champs, or M. Fauchey, 3, rue de Louvre.

Budapest.—M. Victor Popp has withdrawn his tender for the supply of compressed air to Budapest on the ground that as he has no electric light concession, compressed air alone would not pay.

Verviers.—Tenders will be received till 9th February for an electric installation for the theatre at Verviers. The specification will be sent for 2f. and plans for 40f. on application to M. Ch. Thirion, rue Franchée, Verviers.

Brighton Electric Railway.—At the last meeting of the Brighton Town Council the question of entering into an agreement for the use of a portion of the foreshore for the electric railway was brought up, but was adjourned.

Taunton.—The matter of purchase of the Taunton electric station by the Town Council is still under the consideration of the Lighting Committee, and nothing definite will be settled till after the Council meeting in January.

A Large Ammeter.—The Weston Electrical Instrument Company, of Newark, New Jersey, are constructing which is supposed to be the largest ammeter yet made, to indicate 5,000 amperes, for the Willson Aluminium Company.

Philippopolis.—An exhibition will be held at Philippopolis in September, 1892, and is announced as an excellent opportunity of introducing new machinery into the Balkan territory. M. A. Gobiet, Prague-Karolienthal, Austria, will furnish particulars.

Personal.—Mr. M'Clean, who used to have charge at the Grosvenor Gallery and afterwards went to Deptford, has now sole charge at the Oxford central station. He is also superintending the exhibit of Elwell-Parker dynamos at the Crystal Palace Exhibition.

State Control of Belgian Telephones.—The Belgian Government, states a Reuter's telegram of Dec. 30, has informed the Belgian telephone companies of its intention to resume from January 1, 1893, the working of all the telephone lines in Belgium.

Consulting Engineers.—Mr. Frank J. Sprague, Dr. Louis Duncan, and Dr. Cary T. Hutchinson have united to form a limited company, having offices at 15, Wall-street, New York, as consulting electrical engineers, to advise and report upon electrical engineering enterprises.

Liverpool Overhead Railway.—We understand that, in deference to an agitation amongst the inhabitants of Princes Park, the promoters of the Liverpool Overhead Railway have decided to abandon that part of the project which would bring the railway within the limits of the park.

Madras Tramways.—At a recent meeting of the Madras Municipal Commission it was decided that a tramway concession be granted to Hutchinson and Co., of Craven-street, Strand, W.C., on the conditions submitted by them, subject to a security of Rs. 10,000 being deposited in the bank.

South African Cables.—The Eastern and South African Telegraph Company, Limited, notifies the restoration of its Aden-Zanzibar cable, thus re-establishing telegraphic communication with South Africa by the east coast. Both the east and west coast routes are now in working order.

Manchester.—The invitations for sending in tenders for the Manchester central station are at last issued, and can be seen in our advertisement columns. The conditions of tender can be obtained from Mr. C. Nickson, Town Hall, Manchester, by application in writing, enclosing two guineas, and the tenders must be received by January 20.

Electric Locomotive.—The Thomson-Houston Company, not content with the large locomotive we mentioned the other week, are building another and larger, which is to draw a train at 40 miles an hour. The pull is to be 6,000lb., and the locomotive will weigh 16 tons, and develop 250 h.p. Electric railway traction is stepping along.

Electricity in Mining.—Prof. W. Robinson delivered last week, at Nottingham University College, one of a series of lectures arranged by the National Association of Colliery Managers. The subject was "Electricity in Mining." The lecturer dealt technically with the production of currents and the application to mines in hauling and lighting.

Electric Bicycle Trainer.—The partner of a well-known Coventry bicycle rider, who is an electrician, has invented an electric pacemaker, but cannot induce his

friend to try it. It is an electric arrangement which will stick a pin into the rider when his pace falls below a 2·40 pace, though a switch would be required while getting up speed or stopping.

Pontypool.—At the last meeting of the Pontypool Local Board an extensively-signed petition, asking the Board to adopt some system of lighting other than that of gas, respecting which serious complaints were made, was presented. After a discussion, Mr. G. H. David gave notice that he would propose a resolution dealing with the subject at the next meeting.

Popp System at Paris.—The third Popp generating station at the Quai de la Gare, Paris, was opened on the 3rd ult. This station for electric lighting makes the third the system, which now has plant capable of giving 20,000 h.p. The three services of pneumatic clocks, distribution of power, and distribution of electric light consume at the present moment 6,000 h.p.

Portelectric System.—This system, which dispenses with motors on its cars by shooting a suitably arranged trolley through a series of solenoids, has been thoroughly tested for over a year in one of the suburbs of Boston. The system is now to be tried on a much larger scale, and will be tested in actual commercial service. A company with 5,000,000dols. has been formed.

Acton Hill Works.—Mr. Ronald A. Scott, of Acton Hill Electrical Works, issues a fifth edition of his catalogue, which illustrates the "Actwell" dynamos and motors, and more particularly search-light projectors of the Admiralty pattern, in which department Mr. Scott has had much success. Details of mirrors and of Admiralty pattern switchboards of solid type are also given.

Christmas Presents.—We beg to acknowledge, with thanks, the receipt of blotting pads and almanacks for the year 1892 from Messrs. Crompton and Co., Limited, Mansion House-buildings, and from the Electrical Power Storage Company, of 4, Great Winchester-street. We have also received a calendar from Messrs. T. Fletcher and Co., the well-known gas-heating appliance manufacturers, of Warrington.

New Firm.—We are informed by Sir Frederick Bramwell that from January 1, 1892, Mr. H. Graham Harris, who has for so many years been his principal assistant, will become his partner, and that the business heretofore practised at 5, Great George-street, Westminster, will be continued under the style of "Bramwell and Harris," to whom it is requested all letters on matters of business should be addressed.

Bradford Tramways.—The Local Government Board have sanctioned the proposal that the North Bierley Local Board borrow £10,000 for the purpose of constructing a tramway from Bradford to Wyke. A draft lease is to be prepared for the letting of the Bradford and Sheffield Tramway Company. It is to be hoped that the example of Leeds, with regard to new tramways, will have a fair chance of imitation on this line.

Bacup.—A sub-committee of the Bacup Town Council has been appointed to obtain estimates for the laying on of the electric light, of the probable number of persons who would become consumers in the event of such light being provided, and the following constitute that sub-committee: The Mayor (Mr. Councillor Salmon), Aldermen Greenwood, Hardman, and Shepherd; Councillors Barrowclough, Priestley, Smith, and Stockdale.

Glasgow.—At the meeting of Glasgow Police Commissioners last week, Councillor Gray reported the proposal to light the principal streets by electricity would be practically *taken up*. The streets proposed to be lighted were Argyle-street, Jamaica-street, Buchanan-street, Sauciehall-street, and St. George's-square. If they should carry out this scheme it would make the city more attractive after darkness set in, and also be a preventative of crime.

Bosphorus.—M. Charles Georgi, who already has the concession for lighting by gas of Cadikeng and other Asiatic villages of the Bosphorus, has now petitioned for a 60 years' concession for the lighting by gas or electricity of Pera and Bechiletach. M. Georgi stipulates to construct a station, at the expense of £8,000, capable of giving 42,000 cubic metres of gas for 24 hours, or equivalent, and to pay a royalty of 15 per cent. to the Government.

Electricity in Chemical Industry.—A large international company is now, we are told, in process of formation in England to put to practical proof the inventions in electrolysis made by Mr. C. Kellner, factory director, of Vienna. This discovery appears to be a new method of production of chlorate of chalk and soda, which has proved extremely cheap compared with present methods. The names of well-known heads of large German industries are stated to be on the books.

Utilisation of Water Power.—The United States Consul-General in Frankfort, in a recent report, describes the Lauffen transmission plant as the most momentous experiment in technical electricity ever made since electricity has been rendered serviceable to mankind. After a lengthened description of the details, Mr. Mason concludes: "The way is now open for Americans to harness the wasted energy of Niagara and a thousand smaller cascades and rapids in every part of our great country to the varied purposes of daily life."

Harwich.—The bringing forward of the memorial to the Board of Trade for a provisional order at Harwich was the cause of a considerable scene, several of the councillors denouncing the expenditure of £50 for this purpose as dead loss, one member remarking that he had had some conversation with a gas director, and that if the memorial were dropped the gas company would meet them fairly. It was, however, resolved to seal the memorial, but, nevertheless, negotiations are to be opened up again with the gas company.

Cork Tramways.—A scheme has taken definite shape in Cork, we learn, for the introduction of a new and improved tramway system. The project is the outcome of local enterprise. The centre of the city is first to be served, and afterwards the line will be extended to the suburbs. The present would seem to be a favourable time, therefore, for submitting fullest information to the promoters of the advantages of electric traction, which are more apparent for a new scheme even than for adaptation of an old line.

Fairy Lamps.—Some rather smart work in stage lighting was done last week by the Mining and General Electric Lamp Company. On Wednesday afternoon, at three o'clock, the order was received by telegram from Mr. Oscar Barrett for a set of jewel lamps for the Crystal Palace Boxing Day pantomime of "Forty Thieves." The batteries were ready, but all the fittings had to be made and fixed, and by the next afternoon the ballet were fitted up with 32 brilliant lamps, which shone and sparkled above the limelight like stars.

Telautograph.—We read that a large factory is being erected in America for the manufacture and equipment of the writing telegraph, or telautograph, of Prof. Elisha Gray. This seems to indicate considerable proposed activity in the near future. It will be remembered that the writing telegraph was shown in operation in England, and amongst other places at Mr. J. W. Swan's house, but

nothing further has been heard of it, principally from the refusal, we believe, of the Postmaster-General to license this invention for actual use in England.

Liverpool.—At the meeting of the Liverpool Watch Committee on Saturday a resolution was adopted that the town clerk inform the Board of Trade that the Council object to the provisional order applied for by the Liverpool Electric Supply Company, Limited, and also a resolution that the consideration of the memorial signed by consumers of electricity in Liverpool, requesting the Corporation to give their consent to the application of the Liverpool Electric Supply Company, Limited, for a provisional order, be postponed until the second meeting in January.

Primary Battery Lighting.—The ever-fascinating subject of lighting a small private house with a primary battery is treated in *Cosmos* by M. de Contades in a somewhat novel way, illustrated in detail. The writer describes, apparently from an existing installation, an arrangement for charging secondary batteries from two large sulphate of copper cells with an automatic switch for cutting the secondaries into series. These light 10 lamps, each of ·5 amperes, at 50 volts, for seven hours a day. The capacity of the charging cell, working for the other 17 hours, is 1,020 ampere-hours.

Motor Patents.—The publication has already been made of the contents of an Italian patent granted some time before the construction of the first industrial dynamo, for the utilisation of current from one machine to set in motion a second. The *Bulletin International* announces that another and earlier patent has been discovered, granted June 30, 1866, to Signor Felice Marco, of Florence, for the utilisation of waterfalls for driving electric machines whose current carried by metallic wires should put in motion other receiving electric machines, installed where the power is required.

Electric Carriages.—An electric carriage has been fitted up by Mr. William Morrison, of Des Moines, Indiana, and is illustrated in the *Electrical World* for Dec. 19. It is a handsome waggonette, with light wheels and cushioned seats, with a rotary wheel for steering. The motive power is obtained from 24 accumulator cells placed under the seats, and the motor is connected to the rear axle by reducing cog gearing. The winding is arranged so that reversal of the current reverses the movement of the car. This carriage has been in practical operation in Des Moines for some time, and will soon be shown in Chicago.

Heckmondwike.—A meeting of the Heckmondwike Electric Lighting Committee was held last week. Mr. Hutchinson, C.E., attended, and produced and explained the plan and scheme prepared by him for the proposed lighting of the district by electricity, when it was resolved that the scheme set out on the plan be approved. Mr. Hutchinson also produced and explained the draft specification for the proposed electric lighting from the proposed station in Oldfield-lane, and a resolution was approved authorising the completion of the specification, and that a copy of the same be supplied to each member of the committee. The minutes were approved.

Margam Abbey.—The residence of Miss Talbot in Wales, Margam Abbey, has been fitted up with combined steam and turbine plant. The turbine is of 25 h.p., and the steam engine, of the same power, drives on the same countershafting. Accumulators for 100 lamps are placed in the Abbey, and there are 400 lamps of 16 c.p. in all. The pipes for the conveyance of water power are 18in. diameter, and weigh in all 90 tons. The cables are laid from the engine-house in cast-iron pipes, which also carry six telephone wires for a private exchange. The whole of the work has been carried out by Messrs. Drake and Gorham, Mr. Campbell Swinton being called in as consulting engineer.

Typewriter and Telegraph.—In our note last week upon the use of typewriters in telegraph offices of the United States, it was mentioned that the only objection seems to be the extra noise, the Remington and Caligraph being most used. We are informed by the Typewriter Company that the sale of the Bar Lock typewriter is also very large amongst telegraph companies, for the reason, it is claimed, that the noise in working this machine is less than others. The economy and efficiency accomplished by the typewriters is very suggestive, and the large field here opened will evidently cause keen competition amongst the various makers, as it cannot be very long before their use is introduced almost universally.

Croydon Electric Cars.—Another trial trip of the Jarman electric cars, which are to be run in Croydon, took place on the lines of the Croydon Tramway Company last week. The first journey was made to Thornton Heath quite successfully and smoothly. On returning a slight mishap occurred by running the cars too close together, and a jar occurred which broke a window. The fully-loaded cars were easily stopped, started, or backed. After the trial a luncheon was taken, at which Mr. Archer, of the Electric Tramcar Syndicate, and Mr. Carruthers Wain spoke as to the future of electric tramcars. Mr. Lintilhac, chairman of the syndicate, presided, and there were present several of the directors of the Croydon Tramway Company and members of the Town Council.

Electrical Apparatus.—Messrs. Dorman and Smith, in the new issue of their catalogue which is before us, insist rightly upon their position as first-hand manufacturers of electrical apparatus. They do not undertake bell, telephone, or telegraph work, or installation contracts, but are the more busily engaged in turning out all kinds of switches, roses, fuses, switchboards, brackets, and pendants which are in such large and continuous demand. This demand, indeed, is increasing so fast that Messrs. Dorman and Smith have been compelled to take new works in Salford, and these will soon be in full swing. Besides the very large selection of ordinary fittings for house and ship lighting, special attention is given in the catalogue to Sunbeam lamp fittings, a department that is evidently growing.

Electric Construction Corporation. — An "Accountant" writing to the *Financial News* says that he was so disappointed at the result of the year's work of the above company that he sold out his holding. His reason for so doing was that the profit of £160,036 was gained at an expense of £162,434 (expenses and cost of production, £129,890; depreciation of machinery, etc., £3,099; head office expenses, etc., £11,423; auditors' fees, £105; interest on debentures, etc., £3,949; other expenses, advertising, etc., £13,968), or a loss of £2,400 on the year's legitimate business, and had it not been for the sale of part of the patents for £64,000 no dividend could have been paid. This is exceptional, and he thinks it does not reflect much credit that in spite of the large turn-over the expenses were in excess.

Ipswich.—At the last meeting of the Ipswich Lighting Committee a letter was read from the Board of Trade inviting observations upon a letter from Messrs. Waterhouse, Winterbotham, and Harrison, 1, New-court, Carey-street, in which that firm wrote with reference to the Ipswich electric lighting order: "We are instructed by our clients, Messrs. Laurence, Scott, and Co., to request that this order may be revoked. Our clients feel that it is not

possible to work two electric lighting undertakings with profit in Ipswich, and they have therefore arranged with the Ipswich Electricity Company that the order granted to that company only shall be acted upon. Under these circumstances we trust that the Board of Trade will consent to the revocation of our clients' order." It was resolved to offer no opposition to the revocation of the order.

London Meat Markets.—Mr. William Malthouse, writing from the Central Meat Market to the *City Press*, says: "The tenants of the Central Meat, Poultry, Provision, and Fish Markets have petitioned the Grand Markets Committee of the Corporation to give them the electric light. I should like the members of that committee to have been here these last six mornings, when nearly 10,000 tons of meat were delivered into the market, and carted away to all parts of the metropolis and the country. The superintendent (Mr. Stephens) and his staff must have had a gigantic task, and have done it well, under circumstances of fearful difficulty and danger. What a mighty boon the electric light would have been to us all. A few market tenants on the committee would, by their practical experience, have rendered great service in this matter."

Canada.—The Dominion of Canada is among England's largest colonial possessions, and yet is very little worked by British enterprise. It has an area of 3,382,000 square miles, which represents one-sixteenth of the entire land surface of the globe, considerably more than the whole of the United States. Yet it only has a population of five millions, or about that of London. In electrical fields it might be better supplied, and its resources developed, as by reason of its long winter it offers considerable opening in this department. The Toronto Construction and Electrical Supply Company have recently canvassed the whole country for electrical goods, and have representatives 4,000 miles apart, in British Columbia, and in Halifax, Nova Scotia. The latter town has a climate much like that of England, and is worthy of more support from the old country.

Electric Stores, Limited.—A private company was formed in the early part of the year which is past under the name of Electric Stores, Limited, having offices at 51, Cannon-street, and lately a showroom has been opened at 10, Bow-lane, E.C. The company, as its name implies, is formed for the supply of stores and electric apparatus of all kinds. The chairman is Mr. Albert Hoster, who is the director of the large incandescent lamp factory at St. Nicolas, near Dieppe. These works cover about an acre of ground, and are carried out upon English principles, having cost about £25,000 to erect, English electricians having been taken out for training the workpeople. The Electric Stores have as manager Mr. Tumber, late of one of the telephone companies. The Company are putting up a large exhibit in the Crystal Palace Exhibition.

Cost of Electric Lighting.—In a letter to the *Financial News*, with reference to a recent article on the cost of electric lighting, Messrs. Crompton and Co. say that as engineers and contractors they are prepared to prove under penalty that what is termed the "sheer cost" of producing the electric light is not greater than that of gas, and that this cost has already been reduced to the low figure of 2d. per Board of Trade unit supplied. The discrepancy between this and the figure charged is due simply to the cost of the large plant and the general expenses, which until the load is high bear a large proportion to the sheer cost. Mr. Harston, writing next day, states that whatever the actual cost may be, from the House-to-House Company (with whom, however, he wrongly associates Mr. Crompton) *the cost is three times* that of gas, and he adds that three 8-c.p. lamps are not equal in light to three 5ft. Peeble's burners.

Reading.—The question of the public lighting of Reading is being pressed for immediate settlement, and it is to be hoped that an arrangement can be come to for lighting the principal streets and the muncipal and other offices by electricity. The Lighting Committee have presented a report in which they detailed the terms on which the Laing, Wharton, and Down Construction Syndicate undertook to light the central business area under an alternative arrangement of a five or seven years' contract. The expense would be half as much again as the present charge for gas, and the light would be about 15 times as much as that now in use, besides which the electric light would be kept alight the whole night, whereas the gas is shut off or cut down part of the night. An amended estimate, by which the arc lights can be shut off at eleven o'clock, substituting incandescent lamps after this hour, is also prepared, and this arrangement being less expensive would probably be favoured by the Council.

Leeds Electric Tramway.—The combination of Christmas and fog has brought about conditions in Leeds which have tested, as well as anything could possibly do, the capacity of the Roundhay Park electric railway. The dense fog was the worst ever known at Leeds, but in spite of the weather the cars have been crowded at every journey, running 500 car miles a day. Through all this no trouble whatever has been found in the electrical part of the work. The engine-room has been running as smoothly as clockwork, the only accident being a little collision between two of the company's own cars, due partly to the dense fog, but also to carelessness of the driver, who was dismissed. The holiday traffic has been very heavy, and it is indeed marvellous, considering both the conditions we recorded, of quick work needed for first installation and the subsequent bad weather, that the Thomson-Houston Company have at once made such a success of their line. The line will very shortly be run down into the centre of the town.

Helsten (Cornwall).—On the 14th of October, the Helston Town Council, at a special meeting, passed a resolution that application be made forthwith to the Board of Trade for a provisional order. Since that time the municipal elections have been held, and were fought to some extent upon the lighting question. At the last meeting of the Town Council a resolution was brought forward to rescind the above. Mr. Taylor moved an amendment that all action should be left pending negotiations with the gas company. He said that the reason the burgesses were opposed to the electric light was that all sorts of stories had been told them at election time, that the rates would be raised 4s. or 5s. in the pound, and so forth. He objected to throwing themselves into the hands of the gas company, with gas at 5s. 10d. per 1,000ft. The Mayor thought it would be wrong to introduce the electric light on the terms which had been mentioned by Mr. Veale, and said the gas company would deal fairly with the Corporation. After further discussion the resolution was rescinded, the Mayor giving a casting vote.

Dundee.—A meeting of the Property Committee of the Town Council was held last week, when it was explained obstacles had arisen in the way of the Gas Commission acquiring the Ward-road site as a station for the electric lighting works, and it was agreed, at the request of ex-Provost Brownlee, to take about 60 poles of the ground belonging to the town at the Old Cattle Market at £2 per pole, with a view to the Gas Commissioners securing that as a site for their electric light station. The ground at present is partly leased to Messrs. Livermore Brothers, and partly occupied as a yard by the Water Commissioners at

a rent of about £60 per annum. The Electric Lighting Committee has thus practically adopted the alternative proposal which was originally defeated at the meeting. About six weeks, however, must elapse before the ground can be obtained. As it is beyond the compulsory area, way leave for the cables is necessary, and on Monday Councillor R. D. B. Ritchie brought the matter up at a meeting of the Works Committee of the Police Commission, at which it was agreed to grant the way-leave.

Private Exhibition in Ireland.—The Electrical Engineering Company of Ireland entertained their friends the other day with an exhibition of electric light illumination for indoor decoration, comprising early tea, a combination much enjoyed by the fair sex. The novel arrangements on the tables and throughout the rooms were particularly admired. On the tea-table some of the incandescent lamps of various colours were entirely enclosed within a light Persian drapery—a striking method of decoration which is only possible where the electric light is available. The general illumination of the room was effected by means of a central electrolier, artistically decorated with festoons of prepared seaweed, and from the ceiling depended a number of pearl shells, similarly decorated, and through which a charming iridescent light was diffused. The visitors were shown over the establishment, the working of the gas engine, dynamo, and storage batteries being explained. A device constructed of small incandescent lamps, arranged in the form of the initial letters of the company, "E.E.C.," brilliantly illuminated the window and footpath.

Covent Garden Carnival Ball.—The Covent Garden Theatre was a brilliant scene on Wednesday night, when the first of Sir Augustus Harris's carnival fancy dress balls was held. The floor had been raised to the level of the stage, and the immense horseshoe shape was covered with a prepared canvas for dancing. Above the stage, raised on fluted white and gold columns, was the orchestra, comprising some hundreds of performers. The music, as may be imagined, was the finest that dancers could wish. The house, in gold and crimson, was brilliantly lighted up with hundreds of incandescent lamps turned on for the first time on this occasion. The sides and balconies were a mass of lovely cut flowers, and the numerous stalls were all decorated with magnificent bouquets. At half-past eleven dancing commenced, and soon after twelve the whole floor was a maze of moving figures, most of them in fancy costumes, making a most imposing and gay assemblage. Dancing was kept up till five or six. We should mention that the electric light was fitted up by Mr. Forrester, their own gas engineer, and the current was supplied by the Metropolitan Electric Light Company.

Bernardos Welding Process.—A large party inspected on December 21st the installation of the improved Bernardos electric welding system at the works of Messrs. Lloyd and Lloyd, Halesowen, proprietors of the patents in this country. The Bernardos process, as distinct from the Thomson process, uses an arc for the purpose of fusing the metal. In actual use a continuous-current dynamo is connected to a set of accumulators, and at the moment of welding both are used in parallel. The work, such as an iron tube, is laid on a metal table which forms one pole. The other cable is connected to a large carbon rod much like soldering-iron, and the arc is struck between the carbon and the tube, the arc being sometimes as much as 6in. long, and of one or two square inches in sectional area. The current used is varied from 10 amperes to 400 amperes. Demonstrations were made of the welding of tubes, wheels, and rods, and of the cutting up of thick iron plates to shape with great success. The later improvements consist in an arrangement for rotating and vibrating the arc to distribute the heat, and an electric power hammer is used to finish the welds. Amongst those present were Sir Redvers Buller, Sir Frederick Abel, Sir Douglas Galton, Prof. Forbes, Mr. McFarlane Gray (Board of Trade), Mr. J. Spencer (Newcastle-on-Tyne), Mr. W. H. White (Admiralty), and Mr. J. Howard, M.P., representing the firm. The firm have granted licenses for the use of the system to Messrs. John Spencer and Sons, Limited, of the Newburn Steel Works, Newcastle-on-Tyne, and other firms.

Electric Organs.—The subject of electricity as applied to large organs is occupying a great deal of the attention of professional organists and organ builders, and Mr. R. Hope Jones, of Birkenhead, who has made a speciality of the question, in his address on "Electrical Control of Organs," on December 19th, before the Yorkshire division of the National Society of Professional Musicians at Leeds, gave some interesting details of his work. Mr. Jones first glanced at the forms of organ action—mechanical, pneumatic, tubular-pneumatic, and electro-pneumatic. With the latter all tubes were removed for a small electric cable, and the pneumatic part was much simplified. He expressed the conviction that the electric would shortly be the only form that organ builders would use in constructing large or moderate-sized organs. Sufficient current to work a large four-manual could be supplied by a single dry cell, and a few shillings would supply a new cell. The organist then became simply a toucher of wires. Noticing the advantages which made the electric action irresistible from an organist's point of view, Mr. Jones mentioned light and adjustable touch. The rapidity in response and repetition secured was really wonderful, mechanical tests proving this action to be capable of no less than 1,300 clear repetitions per minute. In connection with the details of his own system there was one feature which he published for the first time that afternoon. He referred to what he termed the "second touch," the object of which was to give, as far as possible, to the organ keys the individual expressiveness of the pianoforte. He applied this second touch to each of the manuals and to the pedals. Among the other advantages which electricity offered he enumerated the following: Movable console; stop keys, saving the organist labour and giving better control of the registers; the stop-switch, by which combination of stops might be arranged beforehand and brought into use at the moment required; unlimited combination touches; keys or studs for the automatic control of the pedal registers; suitable accompaniment; unlimited couplers; increased control of the swell shutters; and the transposition switch. The only single disadvantage that could be named was the need for a supply of electric current, but as they could obtain all that they required from a single cell, they need not fear inconvenience from this. Mr. Jones said that he had always felt that but for the enterprise of Messrs. Abbott and Smith his attempts in regard to electrical organ control would never have led to any greater results than the experimental organ in St. John's Church, Birkenhead. A year ago that instrument was of little interest to anyone but himself and the choristers, who helped him to build it. The organ had, however, during the year been visited by nearly 1,500 musical gentlemen, and 23 London and provincial organ builders were now duly licensed and engaged in the introduction of the system. The meeting passed a hearty vote of thanks to Mr. Jones for his address. The company then visited the factory of Messrs. Abbott and Smith, and inspected the model of an electric organ which the firm is erecting.

OUR PORTRAITS.

Crookes, William, F.R.S., P.P.C.S., President of the Institution of Electrical Engineers, 1891. Born in London in 1832; entered Royal College of Chemistry in 1848 as a pupil of Dr. Hofmann, and gained the Ashburton Scholarship in 1849. In 1850 he became junior, then senior, assistant to Dr. Hofmann, which position he retained till 1854, when he obtained the appointment of superintendent of the Meteorological Department of the Radcliffe College, Oxford. Elected a Fellow of the Royal Society in 1863. Mr. Crookes founded the *Chemical News* in 1859, of which paper he is still the proprietor and editor. Mr. Crookes has been president of the Chemical Society and of the Chemical Section of the British Association. He is an indefatigable investigator and writer, and his researches upon high vacua stamp him as one of the foremost of the scientific men of the nineteenth century.

Ayrton, Prof. W. E., F.R.S., President of the Institution, was educated at University College School, where he gained numerous prizes, and entering subsequently into the college, gained the Andrews Exhibition in 1865 and the Andrews Scholarship in 1866. Subsequently Mr. Ayrton entered the Indian Telegraph Department, first studying under Sir W. Thomson at Glasgow. In India Mr. Ayrton did good and lasting work with the late Mr. Schwendler. From 1873 to 1879, Prof. Ayrton was Professor of Natural Philosophy and Telegraphs in Japan. Since his return to England his name, often in conjunction with that of his colleague, Prof. Perry, has been constantly before scientific circles. The number of papers he has individually, or in conjunction with others, contributed to the learned societies is very great. His career at the Finsbury College, and subsequently at the Central Institution, is well known to most of our readers, who, if they require an example of extraordinary energy, coupled with great abilities, cannot do better than emulate the President of the Institution for 1892.

Webber, Major-General Charles Edmund, C.B., R.E. (retired), Past-President of the Institution, and one of the two founders, his colleague founder being the late Sir Francis Bolton. Born in Dublin, 6th Sept., 1838. Educated at the Royal Military Academy, Woolwich, and obtained his first commission in the Royal Engineers in April, 1855. Major-General Webber's war services comprise the Indian Mutiny, 1857 to 1859, and he was attached to the headquarters of the Prussian army in the Austro-Prussian War of 1866. He was employed in Asia Minor in collecting transport for the Abyssinian Expedition. In 1879 and 1880 he was in Zululand, Natal, and latterly in the Transvaal, with the Egyptian Expedition of 1882, employed as staff-officer for telegraphs; present at the battle of Tel-el-Kebir, A.-A. and Q.-M.-General and Director of Army Telegraphs with the Nile Expedition of 1884-5, until invalided in May, 1885, retired from the service with the honorary rank of major-general in 1885. Of late years General Webber has been closely connected with electrical engineering, and especially with the Brush Company and the Chelsea central station; also with the system of main-laying known as the Callender-Webber system.

Preece, W. H., F.R.S., Past-President of the Institution. Born 1834, near Carnarvon. Educated at King's College, London. Entered Mr. Edwin Clark's (M.I.C.E.) office in 1852. Appointed to the E. and I. T. Co. 1853. Superintendent of the southern district of E. and I. T. Co. 1856, and of L. and S. W. Railway Co. in 1860; also engineer Channel Islands Telegraph Co. 1858; transferred to P.O. as divisional engineer 1870; appointed electrician 1877. If we say little more of Mr. Preece's career, it is not from lack of material but from lack of space. In fact, it seems almost a work of supererogation to attempt to make more prominent one of the most prominent figures of the age in electrical and telegraphic circles. Like other eminent men, the list of his contributions to the scientific literature of to-day is very extensive, and we only regret that he has not found time to add further to it by a contribution to our columns. If the idiosyncrasies of Mr. Preece were sought out, they would probably be found to consist of a thorough groundwork of strong common-sense, and a special ability to popularise his subject. More power to his elbow.

Webb, F. H., secretary to the Institution, was educated at the Ecole Normale, at Brussels, and University College, London. He afterwards went to Germany to study for the profession of an engineer. Then for six years he held the post of resident-secretary and librarian to the Royal Institute of British Architects. He was in the engineer's office of the first telegraph company, and for 10 years was private secretary to the late J. L. Ricardo, M.P., founder of that company. Mr. Webb subsequently held secretaryships to several companies, and amongst others that of assistant secretary to the London and Brighton Railway. Upon the resignation of Mr. Langdon in 1878, he was appointed editor of the Institution of Electrical Engineers' *Journal*, and secretary to the Institution, which latter position he has held up to the present time. The great interest he takes in all that concerns the Institution is well known to members. It is by no means an easy task to steer a great institution through the quicksands of public criticism, and we venture to think that Mr. Webb has by his constant and unwearied courtesy done much to raise the Institution to its present pitch of prosperity.

Salomons, Sir David L., Bart., one of the Vice-Presidents of the Institution, was born in 1851, and educated by private tuition, and at Caius College, Cambridge, where he graduated in the Natural Science Tripos. Sir D. Salomons has done excellent work of recent years in assisting forward electrical engineering in several departments. A great debt of gratitude is due to him by the profession by his thoroughly exhaustive test, under private and unbiased auspices, of electric lighting at his residence near Tonbridge, where also he was one of the first, if not the first user on a practical scale of secondary batteries, and of motors applied to actuate his various lathes and similar machines. The results of his experience have been given to the world in the shape of a book, which has run through several editions, and is justly esteemed as giving practical experience instead of theoretic ideas. Sir D. Salomons has done good scientific work in other directions, but to us his personality and his tastes tend more to electrical matters than elsewhere. We trust that the Institution will recognise all he has done for electrical progress by electing him in due order to the presidential chair.

THE CRYSTAL PALACE EXHIBITION.

A generation has come and gone since the Crystal Palace became one of the institutions of England. Of the hundreds of thousands who annually enter its doorways but a small percentage know aught of the history of the edifice. In prospect, therefore, of the interesting exhibition now about to be held within its portals, a brief history of the building may not come amiss. England owes far more to the Society of Arts than is generally credited. Its work, as a society, commenced in 1754, but its first exhibition of arts and useful inventions was not held until 1761. The interval between 1761 and 1851 saw a variety of exhibitions initiated by the society, and other societies, mainly agricultural. Probably, however, the various exhibitions held in Paris from 1797 to 1849, gave rise to the idea of an international exhibition in 1851, to be held in London. In 1848 the Council of the Society of Arts made a suggestion, which, through its then president, the Prince Consort, ultimately led to the 1851 exhibition in Hyde Park. A Royal Commission was appointed, and among its work was the selection of plans for the building. Early in 1850 the Building Committee advertised for plans, and in reply received 233 plans. Out of this number only 18 could be found worthy of commendation, and not one for selection. The committee then prepared a hybrid composition according with their own view, which elicited a storm of disapprobation. However, the executive were in a corner—time was passing, and something had to be done. Specifications were being prepared, when a fortnight before they were issued Mr. (afterwards

Sir) Joseph Paxton offered to send another plan if it would be received. Suffice to say it was received, and in the end adopted, giving rise to a building which silenced critics and stamped the author as a constructive genius of the highest rank. The plans when published gave universal satisfaction, but the building itself elicited enthusiastic admiration. It looked like the palace of some genii, so ethereal was its appearance. Only iron, wood, and glass was used in its construction. In form a vast parallelogram 1,851ft. long and generally 408ft. wide, but 456ft. wide in the widest part. To this structure the name Crystal Palace was given by common consent. In it the 1851 exhibition was successfully held, and at its close there was a general desire that the Crystal Palace should not be destroyed. Many wished it to become a permanent building in Hyde Park, but that was not to be. A company was formed to purchase the materials of the building, remove, and re-erect it elsewhere. This company obtained 171 acres of land from Mr. Leo Schuster at Penge Park, and 178 acres additional whereon to erect the building and lay out adjoining grounds. A part of this land was not required, and was sold. On the site selected the first column of the building was raised on August 5th, 1852, and the building was publicly opened on the 10th June, 1854. The Crystal Palace at Sydenham, as we know it, is not an exact reproduction of the exhibition of 1851, but a more perfected building. Unfortunately, at the present day it is partly shorn of its pristine glory, a part having some years ago been destroyed by fire. It was originally in form a parallelogram running nearly north and south, the length being 1,608ft.; with two wings extending to the east, each 574ft. long; and a railway colonnade, running from the station to the south wing, 720ft. long. The entire length of the building, therefore, is 3,476ft.—nearly three-quarters of a mile. The greatest breadth is 384ft. The palace is now terminated at each end by a "crystal tower," 284ft. high; erected for the purpose of raising water to the tanks from which the high jets of the great fountains in the lower basins in the grounds are supplied. They were not in the original plan; but they add to the symmetry of the structure, when viewed from the grounds. The elevation on that side (the east is further improved by the necessity for the erection of a lower storey, to give the building the necessary width. This necessity arose from the ground sloping down to the east; and Sir Joseph Paxton suggested that a basement storey should be formed, the roof of which should support the floor of that side of the main building. This storey is entered from the front or grand terrace in the grounds, or from the railway corridor, and access to the main building is gained by staircases at the north and south ends, and in the centre. The main building, above this basement, consists of a grand central nave, two side aisles, three transepts, and the north and south wings. The dimensions of these various parts will be seen in the following table:

	Nave.	South Transept.	Central Transept.	North Transept.	Wings.
Length	1,608ft.	336ft.	384ft.	336ft.	574ft.
Breadth	72ft.	72ft.	120ft.	72ft.	—
Height from the floor to the springing of the arch	68ft.	68ft.	108ft.	68ft.	68ft.
Height to the crown of the arch	110¼ft.	110¼ft.	174¼ft.	110¼ft.	110¼ft.
Height from the basement	—	—	202ft.	—	—

The entire roof of both the nave and transepts is a vaulted arch, that of the Central Transept being 120ft. span. Between each end, and the North and South Transepts, the distance is 144ft.; and between each of those transepts and the Central Transept is 528ft. The general width of the body of the building between the transepts is 312ft. The difference between that and 384ft. is made up with glazed and open corridors. In the garden fronts of each of the three transepts are recesses 24ft. deep. "These throw fine shadows and take away from the continuous surface of plain glass walls; while the whole general arrangement of the exterior, the roofs of the side aisles rising step-like to the circular roof of the nave, the interposition of low square towers at the junction of the nave and transepts, the open galleries towards the garden front, and the long wings stretching forth on either side, produce a play of light and shade, and break the building into parts, which, without in any way detracting from the grandeur and simplicity of the whole construction, or causing the parts themselves to appear mean or small, present a variety of surface that charms and fully satisfies the eye."

The Crystal Palace, then, is *par excellence* the home of exhibitions, and no better building could have been selected for an electrical exhibition. During the 10 years since the last was held in this building great progress has been made, and it is to be hoped the forthcoming exhibits will sufficiently illustrate the present position of the industry.

PROGRESS AT THE EXHIBITION, DEC. 31ST.

We give below a list of the exhibitors at the Crystal Palace Electrical Exhibition, and some preliminary notice may be welcome of how the work of installing the machinery is progressing, with some little foretaste of what visitors may expect to see.

In the first place, we must state that the opening, originally fixed for the 1st of January, has been put off until the 9th, and indeed it is hard to see that the exhibition will be ready to open even upon that date, though a week or ten days makes a wonderful difference in the appearance of an exhibition at the time of opening. At our visit on Wednesday we found hundreds of workmen engaged in putting down machinery and erecting stalls, yet so vast is the interior of the Crystal Palace that no very great inconvenience is noticeable to the promenaders.

The exhibits may be divided into four large sections: First, the main building, down the centre of which from fountain to fountain run a row of large stalls by the great firms—Crompton, Brush, Johnson and Phillips, Siemens, Laing-Wharton, National Telephone Company, General Post Office, Edison-Swan—flanked by numerous smaller exhibits. Second, we have the Machinery Hall, with a magnificent collection of machinery in motion, by some of the same firms, together with Messrs. Davey, Paxman, and Co., and gas engine makers, with Crossley's, of course, conspicuous. Thirdly, there are the galleries, in which a number of rooms are being fitted up with art furniture, and luxuriously furnished with electric light in all artistic shapes—here Messrs. Rashleigh, Phipps, and Dawson are intending to show something astonishing, and Messrs. Cooper and other art decorators are spending large sums in providing beautiful interiors. Lastly, there is a special court in which the railway companies show the signalling systems. There will doubtless be other divisions of the principal features as the exhibition gets into shape, but these seem to be the general features as at present being prepared.

Coming into the Centre Transept, a large stand of Messrs. Johnson and Phillips will first be seen divided into two departments—telegraph and electric light. Huge cable buoys, some crushed from the weight of water at the bottom of the sea, together with grapnels and paying-out apparatus, illustrate cable laying, while the dynamos and Brockie-Pell arc lamps are being rapidly got into place. The handsome lampposts erected at St. Pancras will be shown. Very noticeable will be the two systems of mast for groups of arc lamps shown respectively by Messrs. Siemens and the Brush Company, the former a lattice mast and the latter an immense riveted tube-mast. The Brush Company have a series of dynamos and engines, baby to giant machines, in place. The General Electric Company will be very popular, for besides their switches and general fittings, they will show motors in work and electric heaters for saucepans, curling-tongs, and flatirons. Messrs. Crompton and Co. are well represented, and have several exhibits. Indeed, one seems to see Crompton, Brush, and Siemens everywhere about the place. Messrs. Crompton have one stand for dynamos and motors and arc lamps, with another for a travelling electric crane, to be shown in operation, besides their machinery exhibit. The Electric Stores, Limited, have a large centre stand.

Coming back to the centre of the Transept, Messrs. Rashleigh, Phipps, and Dawson have a large kiosk to be

fitted up as living-rooms, which will make a good show. This exhibit, we hear, is constructed so that it can be afterwards sent over to Chicago. The National Telephone Company are evidently laying themselves out to amuse and instruct; a handsome building is fitted up as a working telephone exchange, with subscribers in the Palace, an immense group of roof insulators overshadowing it. To one side are fitted up half-a-dozen public call-boxes, by which anyone will be able to talk to subscribers in London, while, perhaps, the feature of this branch of the exhibition will be a telephonic concert-room to hold 50 people, where concerts in Manchester, Liverpool, or Birmingham can be heard at charges of 3d. or 6d. for 10 minutes. The Western Electric Company are also fitting up a comprehensive telephone exhibit, being something out of the usual style.

A fine stand will be that of Woodhouse and Rawson, Limited. Already the Kingdon dynamo is in place; Midget arc lamps are being fitted up, and a novelty in the shape of an electro-hydraulic rivetter will attract attention. One of the most prominent exhibits is a church built quarter size, fitted with lightning conductors—whether the disastrous effects of lightning strokes to unprotected buildings will be illustrated does not yet appear.

The most noticeable feature of this exhibition will most certainly be the exhibit of the Edison-Swan Company, who have devised a novel and striking form of drawing attention to the lamps. High from the roof of the Palace hangs an immense number of wires, forming a kind of screen across the space. This screen is wired for electric lamps, and the whole will be covered with incandescent lamps in different sizes and colours, and in varied designs. The screen is to contain 5,000 lamps, half of which are to be used for lighting, and by means of a commutator the various devices will be shown forth in light. As much as 200 h.p. will sometimes be used to light this screen. Below this exhibit are long tables of H.M. Post Office, on which telegraphs of various sorts will be shown in operation.

Down the side arcade we notice the stalls of the Mining and General Electric Lamp Company, Lacombe's carbons, Arcas plating already in operation, Pyke and Harris's high-tension apparatus, Davis and Timmins's nuts and screws, Mr. J. Pitkin's instruments, Mosses and Mitchell vulcanised fibre, Dorman and Smith for switches, Mr. H. Sharpe, of Theobald's-road, with fittings, Blackman's air propellers, besides many others rapidly coming into shape. We should not forget to mention an electric lift, which is being arranged to raise persons from the floor to the gallery.

One of the unfortunate results of the recent fire at Messrs. Laing, Wharton, and Down's has been to throw them all behind with their exhibit. Switchboards and artistic fittings, to the extent of many hundreds of pounds, were prepared, and they were congratulating themselves upon being one of the earliest upon the scene, when the fire occurred, and the whole had to be prepared over again. Messrs. Laing, Wharton, and Down have the whole of what is known as the Entertainment Court. They will remove the stage and fit the room up as a self-contained plant, working together with Messrs. Crossley Bros., who have two Otto gas engines already fixed.

In the Machinery Hall, which lies just behind the Entertainment, whole groups of men are at work till late every night. Messrs. Siemens are perhaps the most forward. They have two huge dynamos, apparently those used in the Naval Exhibition, with switchboards ready fixed. The Brush Company have a series of vertical engines, made at their Falcon Works, being erected to drive alternators and arc machines. Messrs. Crompton have also a large space in the Machinery Hall for engines and dynamos running, the foundations for which are laid. Besides this, Messrs. Davey, Paxman, and Co. are erecting some large engines to drive Crompton dynamos. The firm of Easton and Anderson, who have recently joined the ranks of electrical engineers, are preparing an exhibit here. The Electric Construction Company have not much ready as yet, but no doubt their show will be prominent.

There will be a larger installation of gas engines than has been hitherto seen at exhibitions—the makers evidently laying themselves out to catch such contracts as are thought of for Leicester and elsewhere, where the interests of the electric light company and the local gas company will be united by driving the dynamos by gas. Besides the noticeable display of Crossley Bros., the National Gas Engine Company have a set of plant practically complete. There is an immense Wells gas engine, which will attract notice, and a whole series of Griffin gas engines, Stockport gas engines, and other makes. In the boiler-house Messrs. Davey-Paxman have seven large locomotive boilers in place. As to the rest of the machinery, the Gulcher Company, who, as is well known, now light the Crystal Palace, are taking out all the old machinery and installing new plant, which is to serve as their exhibit at the same time as lighting the Palace. They will have two 40-unit dynamos supplying incandescent and arc lamps on the low-tension parallel circuit, and a 30-unit alternator of the newly-designed Fricker type. These will be driven by the Galloway boilers and the Crystal Palace engines.

Upstairs in the galleries by far the most noticeable exhibit will be that of Messrs. Rashleigh, Phipps, and Dawson, who have probably the largest space in the exhibition. The firm are working in conjunction with the well-known decorators, Godfrey Giles, and Co., of Old Cavendish-street, and the exhibit is being fitted up in very handsome style as living-rooms and conservatory, a small army of men being constantly at work on it. The first room will be a conservatory, built up in a new kind of patent glass hollow bricks. The rockery is being carried out by Mr. Dick Radclyffe, with real rock from Robinson Crusoe's Island. The second room is an Old English hall, and the third an Italian dining-room, while the last is a Japanese drawing-room. Some novel and striking electric light effects will be introduced, and it can be confidently prophesied that this exhibit will be exceedingly popular.

Other beautiful art furniture exhibits with electric light effects will be those of Messrs. H. and J. Cooper, of Great Pulteney-street; Messrs. Allen and Menooch, of Brook-street; and Messrs. W. Wallace and Co. An exhibit of a new kind of underground creosoted wood conduit is already in place by the Macdonald Electric Subway Company, evidently of America; and Messrs. F. Wiggins and Co. will have their mica in full view. Electrical engineers who think that the exhibition will be devoted to their interests will probably be somewhat astonished to find our advertising electropath, Mr. C. B. Harness, very much to the front, intent on riding into the credulity of the public upon the crest of the electrical wave. A whole set of "electropathic treatment rooms" will be in active operation, and a very handsome set of rooms they promise to be. While so little is known about electricity, and all its ways are as "caviare to the general," the "general" will no doubt believe their petty ailments can be cured by the wagging of a needle or the sparks from a huge induction machine, especially if driven by an electric motor. The last exhibit we must now mention is that of the theatre, where the Christmas pantomime is being produced. The stage is being lighted by 300 lamps by Messrs. Rashleigh, Phipps, and Dawson, and the fairy lamps are supplied by the Mining and General Electric Lamp Company.

The public are now becoming rapidly educated in things electrical, and better able to appreciate the uses of the mysterious force. Exhibitions such as this to be opened at the Crystal Palace, serve continually to bring the actual applications of electrical science closer and closer home to both private customers who desire the latest refinements of comfort for their houses, and those, such as engineers, who are constantly on the look-out for means of increasing the efficiency of their manufactures. There is a final point we should like to insist upon here. Exhibitions too often suffer from a want of sufficient description by cards or labels in full and explicit terms attached to the exhibits themselves. Stall-keepers cannot be on the ground all the time; people, moreover, are modest and do not like to intrude too much, and yet are ever avid for information. If this is plainly and prominently set before them, with explanatory details as to theory and application and so forth upon each machine, the exhibition can be made of far greater usefulness all round.

ALPHABETICAL LIST OF EXHIBITORS.

A.	Stand No.
Appleton, Burbey, and Williamson	17, 70
Andrews, J. E. H., and Co.	64, 162
Acme Electric	110, 170
Aubert, M.	125
Allsop and Co.	132
Anderson, R.	166
Archer Pipe Company	207A
B.	
Brush Electrical Engineering Company	4
Borting and Co.	25
Barclay and Son	26, 66, 204
Blackman Ventilating Company	33
British Electric	46
Browett and Lindley	51, 52
British Gas Engine Company	73, 75
Bourne, J., and Sons	78
Berg, E.	108
Benham and Froude	117
Bristol, L.	136
Birmingham Telegraph Company	155
Bowron, G.	171
Bishop, W. J.	211
British Stone Company	224
Becke and Co.	226
Britannia Rubber Works	227
C.	
Crompton and Co.	1, 11, 14, 43, 220
Cathcart, Peto, and Radford	27
Conradty and Co.	31
Crossley Bros.	44
Campbell Gas-Engine Company	60A, 69
Churchill and Co.	79
Croggon and Co.	107
Consolidated Telephone Company	106, 216
Chubb and Sons	111
Cutling, Douglas, and Co.	161
Cooper, H. and J. S.	203
Crofts, A.	208
Coxeter and Son	215
Cash and Co.	221
D.	
Day and Co.	16, 58, 76
Dorman and Smith	22
Davey, Paxman, and Co.	60, 61
Dick Kerr and Co.	67, 68, 201
Drury, W.	152
Davis and Timmins	189
Dent and Co.	38
E.	
Electrical Power Storage Company	8
Epstein Accumulator Company	9, 173
Electric Stores	13
Easton and Anderson	42
Electric Construction Corporation	49
Evered and Co.	121
Edison and Swan United Electric Light Company	138
Electric Installation and Maintenance Company	135
Economic Electric Supply Company	149
Elliott, A., and Cheetham Strode	168
Electropathic and Turkish Baths	213
Exchange Telegraph Company	177A
F.	
Faraday and Son	12
Freeman, W. S.	49A
Fielding and Platt	74
Fowler, Lancaster, and Co.	117A
Floyd	135
Fowler-Waring Cables Company	160
Fox, E.	214A
G.	
Gulcher (New) Electric Light Company	6
General Electric Company	7
Gill and Co.	28, 56
Graham and Biddle	118
Glover, W. T., and Co.	141
Groth, L. E.	144
Groves, W	146
Groombridge and South	150
Giles, F., and Co.	205
Green and Son	23
Gordon, J. E. H.	128
H.	
Hartnell, Wilson	30
Hindley, E. S.	77
Hodges and Todd	105
Homacoustic Co.	112
Harris, J.	176
H.M. Post Office	133
Habgood W.	158
Hookham, T., and Co.	222
Henley's, W. T., and Co.	159
I.	
International Electric Company	164
Ingersol Serjeant Drill Co.	126
J.	
Jenner, T.	142
Jennings, G.	154A
Joel and Co.	157
Johnson and Phillips	10, 80
Joslin, P.	85
Joel, A.	120
K.	
Kelway, C. E.	129
L.	
Laing, Wharton, and Down Syndicate	41, 45
London Metallurgical Company	109
Lacombe and Co.	114
Lundberg, A. P.	119
L. C. and D. Railway	178
L. and N. W. Railway	179
L. B. and S. C. Railway	181, 182
Levi, S. H.	218
Lewis, J.	131
M.	
Mosses and Mitchell	20
McKinnel and Co.	62A
Mosser, F.	185A
Maquay Electric Light Company	115
Mining and General Electric Lamp Company	147
Morgan-Grenville	174
Moore, A. F.	177
Medical Battery Company	214
Marryat and Co.	219
N.	
National Telephone Company	191, 101
Napier and Sons	180
Nalder Bros.	130
Newton, F. M.	57
O.	
Osler and Co.	5
P.	
Pitkin, J.	175
Pyke and Harris	167
R.	
Richard Frères	153
Richards, J. M.	3A
Rylands, D.	36
Renshaw and Mackie	62
Ropers Company	63
Rashleigh, Phipps, and Dawson	101, 202
Rawlins and Walker	156
S.	
Swinburne and Co.	2
Siemens Bros.	3, 48, 192
Shirley and Co.	18
Spencer, J.	24
South of England Electric Company	29, 54
Scott, R. A.	33, 47
Sugden, J.	106A
Sidney and Barnett	123
Scientific Alliance	124
S.C.G. Electrical Company	127
Suter, F.	154
South-Eastern Railway Company	183
Stegman, G.	207
Smith, Newton	212
Shippey Bros.	217
Saxby and Farmer	180
T.	
Todman, J. T.	19
Thompson, H.	21
Trent Gas Engine Company	73
Telegraph Manufacturing Company	140
Thatcher and Devereux	209
V.	
Vaughan and Brown	148
Vogel, C. C.	156
Victor Battery Company	172
W.	
Woodley, R.	34, 50
Waygood and Co.	37
Wells Bros.	71
Woodhouse and Rawson United	103
Weymersch Battery Company	113
Waterlow and Sons	116
Warbey, J. L.	145
White, J.	151
Wake and Saunders	206A
Walker, W.	210
Wiggins, F.	223A

LIST OF EXHIBITORS IN ORDER OF STANDS.

	Stand No.	
Crompton and Co., Mansion House-buildings, E.C.	1	S.N.
Swinburne and Co., Broomhall Works, Teddington	2	,,
Siemens Bros., 12, Queen Anne's-gate, Westminster	3	,,
Richards, J. M., 146, Holborn-viaduct	3A	,,
Brush Electrical Engineering Company, Albert-buildings, Queen Victoria-street	4	,,
Osler and Co., 100, Oxford-street, W.	5	,,
Gulcher (New) Electric Light Company, Battersea Foundry, S.W.	6	,,
General Electric Co., 71, Queen Victoria-street, E.C.	7	,,
Electrical Power and Storage Company, 4, Great Winchester street, E.C.	8	,,
Epstein Accumulator Company, Limited, 34, Cannon-street	9	,,
Johnson and Phillips, 14, Union-court, Old Broad-street	10	,,
Crompton and Co., Mansion House-buildings, E.C.	11	,,
Faraday and Son, 3, Berners-street, W.	12	,,
Electric Stores, Limited, 51, Cannon-street, E.C.	13	,,
Crompton and Co., Mansion House-buildings, E.C.	14	,,
Day and Co., 60, Queen Victoria-street, E.C.	16	,,
Appleton, Burbey, and Williamson, 98, Queen Victoria-street	17	,,
Shirley and Co., 45, Rathbone-place, W.	18	,,
Todman, J. T., Queen-street-chambers	19	,,
Mosses and Mitchell, 68, Chiswell-street, E.C.	20	,,
Thompson, H., 59 Theobalds-road, W.C.	21	,,
Dorman and Smith, Brazenose-street, Manchester	22	,,
Green and Son, W., 98, Albany-road, S.E.	23	,,
Spencer, J., Globe Tube Works, Wednesbury	24	,,
Borting, J., and Co., 30, Berners-street, Leicester	25	,,
Barclay and Son, 178, Regent-street, W.	26	,,
Cathcart, Peto, and Radford, 57B, Hatton-garden, E.C.	27	,,
Gill, A. B., and Co., 36, Parliament-street, Westminster	28	,,
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TELEPHONE INSTALLATION.

Mr. Langdon, the telegraph superintendent of the Midland Railway Company, has lately installed a complete telephone system at The Adelphi Hotel, Liverpool. The installation comprises three floors, and on each floor is a switchboard for 70 directions—making a total number of 210 stations. Each room is fitted with a call-box and a double "Ader" instrument (magnetic transmitter), a separate call-bell and a three-contact pear-push, which is suspended near the bed, so that the visitors can ring in the usual way or communicate through the telephone. The visitors are able to communicate with one another and with the staff of the hotel, this effecting considerable saving of time both for visitors and staff. This installation has given great satisfaction, as it is simple and thoroughly reliable. It is similar to the large installation at The Terminus Hotel, Paris, where 350 rooms are connected, the only difference being that in the latter "Ader" microphones were used instead of magnetic transmitters. The instruments and appliances for the above installation were supplied by La Société Générale des Téléphones.

PHYSICAL SOCIETY.—Dec. 18, 1891.

Prof. W. E. Ayrton, F.R.S., president, in the chair.

Mr. R. W. Mond, F.R.S.E., was elected a member of the society.

The **President** announced that it had been found necessary to alter the dates of the meetings to be held after Christmas from those already published to the following: January 22nd, February 12th and 26th, March 11th and 25th, April 8th, May 13th and 27th, June 10th and 24th.

A "**Note on Interference with Alternating Currents**" was communicated by **Mr. M. H. Kilgour.** Whilst studying Dr. Fleming's paper on "Some Effects of Alternate-Current Flow in Circuits having Capacity and Self-Induction,' the author constructed some additional curves. He was thereby led to investigate whether the serious rises of pressure produced by adding capacity would occur over considerable ranges of capacity, or whether they would only take place when the capacity was nearly equal to a particular value. Taking the case of a condenser of capacity C farads, in series with a circuit of resistance R ohms, and inductance L henrys, he showed that the maximum value of λ (the ratio of the pressure across the condenser terminals to that across the condenser and inductive resistance) is obtained when $C = \frac{L}{R^2 + p^2 L^2}$ (1), where $p = 2\pi$ times the frequency. The maximum of λ produced by this capacity being given by the expression $\Lambda = \frac{\sqrt{R^2 + p^2 L^2}}{R}$ (2). Taking R = 10 and $p = 2\pi$, 1,000 curves plotted from equations (1) and (2) between C and L, and between Λ and L had been drawn. The C L curve rises to a very sharp peak at L = ·0015 and falls rapidly. That between Λ and L starts horizontal and bends upwards, and approximates to an inclined straight line for values of L greater than 0·002, when L = 0·1, Λ = 63. Considering the question of the range of capacity with which a given rise of pressure can occur, it was pointed out that when the values of L, R, and p are such as to make a large rise possible, a rise exceeding a moderate value can only be obtained for values of C differing little from that given by equation (1). On the other hand, when the circuit is such that the maximum rise possible is not large, then a rise exceeding a given moderate value can be obtained over a much wider range of capacity. Hence, the author concludes that the larger the possible rise the smaller is the probability of a serious rise occurring. The effect of shunting the condenser by a circuit of resistance, r, and inductance, l, is next dealt with in the paper, and the values of C which make λ a maximum determined, as well as the maximum value λ can have. Subsequently the author examines whether the practical case of an alternator feeding a transformer through a concentric cable may be simplified without introducing serious error by assuming the capacity concentrated at either end of the cable, and concludes that in ordinary cases little error will be thus made. In an experiment made with a 100-kilowatt alternator, three-quarters of a mile of $^{7}/_{16}$ concentric cable, and an 18-kilowatt transformer, a rise of ¼ per cent. was found to occur at the terminals of the alternator when the cable was connected. Putting on the transformer unloaded or loaded produced little change in the rise of pressure; this in all cases being between 0·2 and 0·3 per cent. **Dr. Sumpner** asked whether the conclusions as to the range of capacity with which a given rise of pressure was possible, was true for small rises such as occur in practice. Cases where the maximum possible rise was of the order 63 were not likely to occur at ordinary frequencies. The highest rise he had ever known was 11. He thought the time-constant of the inductive coil chosen—viz., $\frac{1}{15}$ of a second—was very large. In circuits containing iron it was practically impossible to get such large time-constants, for the power spent in the iron increased the effective resistance. Referring to the narrow range of capacity within which large rises were possible, he pointed out that such cases were found in Hertz's resonators, where the rises were immense, but to obtain them the adjustments had to be very accurately made. **Dr. S. P. Thompson** said he regretted that Prof. Fleming was not present, for he had recently investigated Hertz's experiments and had obtained curves very similar to that got for the Deptford mains. The curve between Λ and L was very interesting. It was, in fact, a curve between the secant of the angle of lag and L, as could be seen from formula (2). In practice one would be working on the lower portion, and hence the rises would be small. **Mr. Kilgour** explained that in the paper his first object was to show that the product of the range of capacity between which a rise greater than a given value would occur and the maximum possible rise, was approximately constant for different circuits. Secondly, he wished to prove that the capacity of concentric cables could be assumed to be localised at either end without introducing much error in the rises of pressures calculated therefrom. **Dr. Thompson**, speaking of nomenclature, regretted that the word inductance should be used sometimes for L, and at other times for L p, and thought its meaning should be restricted to the latter. **Prof. Perry** said a name was needed for coefficient of self-induction. Resistance was practically independent of frequency, and "inductance" should have no reference to frequency. **Dr. Sumpner** thought it important to have a name for L p, for that quantity comes into calculation most frequently. He would have preferred that "inductance" should mean L p, but Mr. O. Heaviside, who introduced the term, had used it for L. The **President** remarked that some time ago Dr. Sumpner and himself felt the need of a name for L p, and thought of using "inductance," but on referring to Mr. Heaviside's articles found it used for L. **Dr. C. V. Burton** asked whether the word "self-induction" could not be used as an abbreviation for "coefficient of self-induction." **Dr. Thompson** pointed out that this word already had a meaning—viz., L multiplied by current. **Dr. Burton** then suggested that inductivity might be applicable. **Dr. Thompson** said the word "impedance" was also used ambiguously, for the sense in which Dr. Lodge uses it in his "Modern Views of Electricity" is not the same as the vector sum of R and L p. **Prof. Perry** recalled the fact that "impedance" had been defined by the committee of the British Association as the ratio $\frac{\text{effective voltage}}{\text{effective current}}$. **Dr. Thompson** said this definition was only applicable to periodic currents, and not to intermittent or transient ones. The **President** said he understood the first object of Mr. Kilgour's paper was to enquire whether the dread of rise of voltage occurring when concentric mains were used, need exist. When Dr. Fleming's paper was read, the general idea was that concentric cables were dangerous. In the discussion on it, he, amongst others, had pointed out that the chance of a large rise of pressure was not a serious one. Mr. Kilgour had now shown that the range of capacity over which a particular rise could occur, is inversely proportional to the maximum rise possible in the particular circuit. When the circuit was such that a large rise was possible, the probability of any serious rise taking place was very small, hence the fears of large rises were more or less unfounded. The second part of the paper was to show that ordinary problems on concentric cables could, in practical cases, be treated with sufficient accuracy by assuming the capacity localised at either end of the cable, instead of distributed along its length.

THE

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TO CORRESPONDENTS.

 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

TO ADVERTISERS.

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NOTICE.

With this copy of the Paper is issued a Supplement containing a sketch of the scene at the Institution dinner, by W. M. BOWLES, with six portraits, taken from photographs, of **Prof. W. Crookes, F.R.S., Prof. W. E. Ayrton, F.R.S., General Webber, C.B., Mr. W. H. Preece, F.R.S., Mr. F. H. Webb,** and **Sir D. Salomons.**

Every reader should see that he gets this Supplement, and non-delivery with the Paper should be reported at the Publishing Office.

1892.

TO ALL READERS, A HAPPY AND PROSPEROUS YEAR.

Egoism is an article as common as jingoism, hence we may be permitted to claim a little of it, and in the first place speak of ourselves. We claim to pay attention principally to business matters, leaving our contemporaries to discourse on transcendental questions about which no one knows anything in particular, though it pleases them to consider otherwise.

THE DIRECTORY.—The new feature of a weekly trades' directory, introduced to-day, may or may not be of service. At any rate, correspondents from widely different quarters are continually asking for names of firms and men, and it seems to us that while an annual directory well done may be valuable, a weekly directory equally well done will be invaluable. The large directories are limited in circulation, and are partially out of date even at the time of issue. The weekly directory can be corrected every seven days, and must in a short time be fairly trustworthy. The directory we issue to-day is not put forth as perfect—it is tentative only; and we ask our readers' assistance to make it more complete. Utility is required, not mere lists of names and addresses. This is how the matter strikes us as business men. Take one example—electrical engineering. It is extending, installations are increasing. By and by each installation will require periodically a replenishing of stores. The oil merchant, the wire manufacturer, the carbon-rod manufacturer, the incandescent lamp manufacturer, and so on through the whole gamut of trades, send representatives to call upon the officers in charge of installations for "orders." It may suit some of the big makers to fancy they will hold the trade because now they are going on swimmingly. They will have to take the small with the large, and remember "many a mickle makes a muckle," or competition will ultimately leave them without the mickle. In another direction, again, we may urge the benefit of a weekly directory. Readers in Australia, New Zealand, South Africa—aye, even in England, Scotland, and Ireland—have never seen, and are not likely to see, the more pretentious works, yet require certain information. This information they get from the paper, communicate with one or more firms, and business results. Wherever the paper is seen—and it is astonishing where papers are seen—the name on the list gets publicity. It would be altogether too much of the confidence trick to insinuate that our views are entirely for the benefit of our patrons. Not so; we believe in mutual advantage, and have no reason to fear but the effort to do something for the benefit of readers will also redound to our own benefit.

PORTRAITS.—From time to time, in a more or less desultory manner, portraits have been given in various papers, but hitherto nothing has been done in a systematic manner. We venture, then, to commence systematically what has hitherto been

done sporadically. With this issue we give half-a-dozen portraits obtained from photographs, and we have another twenty or so ready for insertion at convenient opportunities. One of the great aims of telegraphists is to find a good way of sending plans, portraits, and pictures telegraphically. We cannot hope to emulate inventors, but follow behind: call in the photographer, engraver, and printer to assist to distribute as widely as our paper is read the representative features of representative men. To obtain a favourable result we require a good, bright photograph, and hope by these means to enable readers who may never be acquainted with prominent men in the flesh to have some idea of what they look like. Had similar views held in the time of Sturgeon and similar means been ready to do the work, we should not now be deploring the loss of his portrait.

THE PAST YEAR.—Several important questions are raised by the work of the past year, but our usual general comments thereon must be reserved for the present. The old year has only just fled, that many who usually favour us with their views have not yet—or too late, owing to the holiday season—placed them in our hands. Meanwhile, we commence to give a *résumé* of the work of individual firms.

ELECTRIC CONSTRUCTION CORPORATION, WOLVERHAMPTON.—In addition to a large and continually increasing amount of business in the supply of machines, switchboards, etc., for private installations, this corporation has carried out some large contracts for continuous-current machines for central lighting stations in London, etc., also some exceptionally large copper depositing plants. They have built a number of the Elwell-Parker alternating-current machines, and supplied large numbers of transformers. They supplied the switchboards and accumulators for the St. Pancras Vestry installation, which has been at work since November last. A somewhat new feature of the past year has been the rapid development of continuous-current transformers. Large central station plants on this system are at the present time being supplied to Messrs. J. E. H. Gordon and Co. for the Installation and Maintenance Company's station at Sydenham, and also for the Oxford Electric Light Company. In addition to these they have supplied continuous-current transformers to other stations. The corporation had completed the electric transmission of power plant in its new works, at Wolverhampton, where all the machine tools, cranes, etc., are driven by means of motors. In addition, they have supplied a number of motors for various purposes, including a set of 60-h.p. hauling plant, and some machines for driving pumps, etc., in collieries. Amongst other important work in hand for the coming year is the contract for supply of generating plant, rolling-stock, and conductors for the Liverpool Overhead Railway.

ELECTRICAL STANDARDISING, TESTING, AND TRAINING INSTITUTION.—During the earlier part of the year some time had to be spent fitting up the new premises, Faraday House, Charing Cross-road, under the superintendence of the heads of the various sections. The standardising and testing departments have had continuous work since they were opened, and as manufacturers and others are getting to find that their instruments can be standardised and calibrated more efficiently at the institution than at their own works, this branch of the business steadily increases, though some firms prefer hiring a private room and doing their own work, the institution supplying apparatus and current. A good deal of work has also been done by experimenters who rent the private rooms, and borrow the apparatus as they require it. Much has been done in the direction of inspecting and reporting upon private installations, testing meters, etc., in cases where disputes have arisen between householders and their contractors or supply companies. Dynamo machines, steam engines, and apparatus generally have also been inspected at the manufacturers to see if they fulfil the specifications, but this work has been chiefly done for agents who are sending plant abroad. Indeed, the necessity for the new departure made when the institution was founded has been clearly shown by the connection already made. In the training department some 50 names are on the books, and it is satisfactory to learn that the companies and firms in affiliation with the institution have already drawn upon it for assistant engineers, the companies usually keeping those apprentices who have been sent them for the purpose of being practically trained and who have shown themselves specially apt for their work. The forthcoming competition for the scholarships and exhibitions seems likely to be large.

INDIA RUBBER COMPANY, SILVERTOWN.—This company has been fairly busy in every branch throughout the year, and in the electrical departments some important orders have been carried out. The cable department laid along the West Coast of South America 1,750 knots of submarine cable for the Central and South American Telegraph Company. Over 1,600 knots of cable have been made and laid along the coast of Brazil for the Western and Brazilian Telegraph Company. Orders have also been executed for cable for the Post Office, the India Office, and various foreign Governments, and about 1,100 knots of a cable to be laid next year between West Africa and Brazil have already been manufactured. The cable department has, in addition, delivered a large quantity of torpedo and electric light cable for shipping orders. For low-tension house-lighting cables and wires the demand still increases, and for high-tension distribution considerable lengths have been manufactured for the Metropolitan Electric Supply Company, the House-to-House Electric Supply Company, the City of London Electric Company. Newcastle-on-Tyne and other towns in England have been large consumers. The company's French factory has filled several orders for the lighting of Paris, Madrid, Barcelona, Tours, Havre, etc. The Admiralty, as a result of past experience, has decided to again adopt india-rubber insulation, and the Silvertown Company, in addition to the Government contract for the year, have obtained a number of orders from the various firms carrying out Admiralty contracts. The instrument department, besides railway, Post Office, and Admiralty work, have executed a number of shipping orders for telegraph and torpedo instruments, and has supplied the whole of the new station switch gear for the London Electric Corporation. The battery department has throughout the year been full of orders, especially for Leclanché cells, which have been supplied in large numbers to Government, and to railway and supply companies. In the electric light department a fair amount of work has been done, including the supply of dynamos and the fitting up of electric light and signal gear on a number of H.M. ships, amongst others the "Blenheim,"

"Blake," "Royal Sovereign," "Grafton," "Theseus," "Repulse," and "Empress of India. Installations of electric light in factories, mills, mines, and private houses have also been carried out, and large number of complete sets of dynamos, cables, fittings, etc., for installation abroad have been delivered. In transmission of power an important order has been executed for a tramway on the Continent, comprising eight cars, which have been in operation for the whole of the summer season. The results obtained are so satisfactory that an additional order has been received for equipment of six 25-h.p. cars, and for the supply of necessary machinery at the station for this extension. In the smaller electrical branches there has also been a good demand.

Paterson and Cooper.—Messrs. Paterson and Cooper have been well employed during the whole of the year, and exceedingly busy during the latter part. As in previous years, shiplighting has furnished a considerable portion of the business, and among the vessels fitted up in 1891 have been the "Nottingham," "Staveley," "Leicester," and "Lutterworth," new steamers of the Manchester, Sheffield, and Lincolnshire Railway Company; the "City of London," "City of Agra," "City of Khios," "City of Edinburgh," and "City of Dublin," belonging to G. Smith and Sons' City Line; "St. Nicholas" and "St. Sunniva," belonging to the North of Scotland, Orkney, and Shetland Company; also the "America," "Berlin," "Furnessia," "Killarney," "Empress of the East," and several others, including the steam yachts "May," "Pathfinder," and "Hermione." The firm has presently on hand the lighting of steamers for the Allan Line, for the General Steam Navigation Company, and for the Clyde Shipping Company. In all manufacturing departments the business has been good. The dynamos have averaged much larger sizes than in previous years, mainly on account of a large number being directly coupled to the driving engines. For machines of large output coupled to double-acting engines the multipolar design is adopted, both Gramme and drum windings being used for the armatures according to circumstances. In arc lamps a good business has been done, a large number having been sold for use on alternating as well as on direct current circuits. The sales in measuring instruments have been well kept up, and the trade in switchboards, fittings, and accessories has considerably increased. During the year complete installations have been erected at the Lancaster Waggon Company's Works, at Bullionfields Paper Mills, Invergowrie; at the residence of G. Peters, Esq., High Elms, Watford; and at Corona, Broughty Ferry, the residence of R. A. Mudie, Esq., the well-known shipowner. Installations of arc lamps have also been completed at the shops of Mr. Lipton, in Dublin, Birmingham, Southampton. Deptford, and London (Edgware-road). Of the wiring of private houses for supply from the various supply companies' mains the firm has had a good share, while among the large establishments wired and fitted may be mentioned Messrs. Combe's Brewery, Messrs. Lambert and Butler's Warehouse, and the St. George's Club, Hanover-square. The firm has several contracts still in hand, the largest being the lighting of the *Daily Chronicle* and *Lloyd's News* offices in Fleet-street, and the refrigerating stores and wharf of Messrs. Nelson and Co. at Lambeth. The former is being wired for 800 16-c.p. and the latter for 1,600 16-c.p. lamps, and both installations will include direct-coupled dynamos and engines complete. For the *Daily Chronicle* offices the dynamos are two in number, with 24in. Gramme armatures, running at 300 revolutions in a four-pole field, and directly coupled to vertical engines 13½in. cylinder and 10in. stroke, made by J. and H. Gwynne. For Nelson's wharf the dynamos, two in number, are also four-pole, and have 25in. drum armatures, running at 200 revolutions, directly coupled to double-crank compound engines. The engines are made by Messrs. J. and H. Gwynne, for whom the installation is being carried out, and have 8½in. and 16in. cylinders with a stroke of 14in.

Robey and Co., Lincoln.—During the year there has been an active demand for engines for electric lighting purposes, not only for isolated installations, but for large central stations. Electricity seems dividing itself now sharply into two classes—viz., independent installations of moderate extent for individual consumers just needing the care of one man to look after them, and in many cases worked by gas engines; on the other hand, large central stations of great extent, taking in an entire town or district. The medium installation worked for a number of customers in a comparatively small district seems, so far as the experience of this firm goes, to be undergoing the process of elimination. Dynamos are increasing in size, as considered by output, and the class of engine most successfully used are those from 200 h.p. to 500 h.p. indicated, which work an independent dynamo. Of this class this firm has made large numbers. Where space is available, and even where it had to be paid for dearly, it is found most economical to use long-stroke horizontal engines worked at high piston speed, but a moderate number of revolutions, and each driving its own dynamo through rope gear. In the Newcastle Electric Light Supply Company's installation (which is one of the largest in England) there are three engines which work to about 200 h.p., duplicates of each other, and Messrs. Robey have just supplied a fourth which will work to about 500 h.p. The size is thought to be one which will be largely used in the future, and will, perhaps, be the most economical for driving a single machine. The reason for suggesting this as a maximum power, is because in cases of accident to either dynamo or engine it is as large a unit in an installation as ought to be thrown out of gear at once, even if it be not too large. For confined situations high-speed vertical compound engines are now being extensively used, and four of these have recently been supplied for the street lighting in London, the two smaller ones being about 100 h.p. and the two larger 200 h.p. each. These larger engines will work easily up to 170 revolutions per minute, and dynamos might be built to couple direct and run at that speed. In the London installation, however, they are being driven by belt, but as there is not a large difference between the size of the driving wheel on engine and the pulley on the dynamo, the belt centres can be kept shorter, and the whole space occupied is very much reduced. Replying to a definite question relating to central station work, Messrs. Robey and Co. say: "The important points, we think, which should be taken into consideration in central station work are the size of the unit of distributing machinery and the method of distribution. As above stated, we think each engine should drive its own independent dynamo, and that all countershafting and gearing connecting one with the other should be dispensed with, and that, with the exception of one smaller engine for running a few lights during the daytime or the small hours of the morning, the engine and machines should be duplicates of each other, with at least one spare one of each. The method of dis-

tribution which seems growing in favour is that of high-tension alternating-current, with transformers. Instead of transformers in every establishment where the light is used, what will probably be found more economical and convenient will be to have transforming stations for a large district. Another matter upon which much has yet to be learned is the construction, insulation, and especially the laying of the cables." Special attention is called to the Newcastle Electric Supply distribution, where Messrs. Robey's engines are used in connection with Mordey alternating-current machines, where the current is being supplied at what is believed to be the lowest price in the kingdom, and probably in the world—viz., at 4½d. per Board of Trade unit. An installation which can do this and make a commercial success of it is one worthy of attention, and the method adopted therein is worthy the study of all parties interested in electric distribution. This firm, it is well known, still continues to supply large numbers of engines both for private and central station installations for the Continent and other parts of the world.

CORRESPONDENCE.

"One man's word is no man's word
Justice needs that both be heard.'

TELEPHONING AT SEA—THE WORD "TELEPHONE."

SIR,—I would suggest that the late Mr. Stuart's "sea telephone" (see p. 579 of your last volume) was nothing more than a method of conveying signals at sea by the agency of sound. In January, 1828, a M. Sudré presented to the Academy of Fine Arts in Paris a system of transmitting words by means of musical sounds, which he called "telephony." It was the subject of extensive experiments, both in the French navy and elsewhere, an account of which may be found in the *Mechanics' Magazine* for July, 1835, p. 269. The inventor visited England in that year, and he explained his method at a meeting of the Royal Society. As an illustration, it may be stated that the word "age" would be transmitted by playing on a trumpet or other instrument the notes *la* (a), *sol* (g), and *mi* (e). In July, 1884, Captain J. N. Tayler, R.N., showed a foghorn, which he called a "telephone," at the Admiralty. The following extract from a newspaper of the day shows what this "telephone" was:

"At an Admiralty *levée*, last week, Captain J. N. Tayler's telephone instrument was exhibited to the Lords Commissioners. The chief object of this powerful wind instrument is to convey signals during foggy weather, when no other means presents itself, by sounds produced by means of compressed air forced through trumpets, which can be heard at a distance of six miles. This important instrument will tend to prevent collision at sea and on railways, and will lessen the horrors of shipwreck and capture, and give notice of fire. Vessels in the offing will be by it directed into harbour, and the time to enter tide harbours made known from the pier-head. Four notes are played by opening the valves of the recipient, and the intensity of sound is proportioned to the compression of the internal air. The small-sized telephone instrument, which is portable, was tried on the river, and the signal notes were distinctly heard four miles off."

The word was used in another sense by Prof. Wheatstone, who says, in his reply to Cooke (W. F. Cooke, the *Electric Telegraph*, 1857, p. 114): "When I made in 1823 my important discovery that sounds of all kinds might be transmitted perfectly and powerfully through solid wires, and reproduced in distant places, I thought that I had the most efficient and economical means of establishing a telegraphic (or rather a telephonic) communication between two remote points that could be thought of. My ideas respecting a communication of this kind between London and Edinburgh you will find in the *Journal* of the Royal Institution for 1828. Experiments on a larger scale, however, showed that the velocity of sound was not sufficient to overcome the resistance and enable it to be transmitted efficiently through long lengths of wire."

I cannot find the paper referred to in the *Journal* for 1828. That for 1831 is the volume in which the paper appears.

In his answer to the above, Cooke says, at p. 260: "In the meantime, the failure at Portsmouth left his [Wheatstone's] submarine conception (with his telephone) in abeyance."

Perhaps some of your American readers will make enquiries about Mr. Stuart's "telephone" and communicate the result to the *Electrical Engineer*.—Yours, etc.,

R. B. P.

ELECTROLYSIS OF GOLD SALTS.

BY ALEXANDER WATT.

In pursuing a series of experiments in the electrolysis of solutions of salts of gold, it was resolved not alone to determine the behaviour of various gold salts under the influence of the electric current, which had received but little attention in an electro-chemical sense, but also to ascertain whether certain other saline substances when subjected to electrolysis in the presence of a gold anode could cause the metal to become dissolved and to enter into the solution. It was the writer's desire, moreover, to see if a solution of gold could be formed in which articles could be electro-gilt of a good deep gold colour when worked at the ordinary temperature of the atmosphere, and thus obviate the necessity of using hot solutions for certain classes of work. It was also deemed desirable to see what modifications in the colour of the deposited gold could be obtained that might prove useful to electro-gilders for producing varied effects upon ornamental work of various kinds. In this connection it was hoped that some of the substances used as precipitants of gold from its solutions would aid the results aimed at. It should be mentioned that all the electrolytes produced by the methods described were tried in their cold state, except where otherwise specified. The current employed was obtained from one-quart Daniell cells, and if two or more cells were required they were coupled in series.

1. *Iodide of Gold and Potassium.*—A solution of this double salt was prepared by gradually adding a solution of iodide of potassium to a neutral solution of terchloride of gold, until the whole of the metal was thrown down in the form of a yellow precipitate of iodide of gold. After allowing the precipitate to subside, the supernatant liquor was poured off, and distilled water added to wash the precipitate, the washing being repeated several times. The last washing water being removed by decantation, a strong solution of iodide of potassium was next gradually poured on to the precipitate, with constant stirring after each addition, until the whole of the iodide of gold was dissolved. The solution, after being filtered, was diluted with about four volumes of distilled water, and was then electrolysed with the current from two Daniells in series, a gold plate being used as the anode and a strip of platinum foil as the cathode. The current proving insufficient, a third cell was connected, and soon after a grey deposit formed upon the platinum surface which in no degree resembled gold; when plunged into cold nitro-hydrochloric acid, however, it tardily dissolved, and its solution indicated the presence of gold, when a drop or two of a solution of protochloride of tin was added, the purple of Cassius being at once produced. A strip of silver was next used as the cathode, the same current being employed, and soon after its immersion it was noticed that a salt of a pink colour formed at that electrode, passing quickly in the direction of the positive plate, and eventually settling at the bottom of the vessel in the form of a red powder. On examining the silver plate, after some minutes' immersion, it was found that a greater portion of the deposit was of a dark grey colour and firmly adherent, while on both sides of the plate there appeared patches of a pretty pink colour, interspersed with the grey film referred to; the only tint of yellow gold appeared at the upper

surface of the back of the plate. That portion of the plate upon which the film referred to appeared was heated over a spirit lamp, when the grey part of the deposit speedily turned a rich deep blue colour, but the pink-coloured patches remained unaltered. On examining the anode the immersed surface was found to be coated with a film of iodine, which readily dispersed when the plate was held over the flames of a spirit lamp. It was subsequently found that when a silver cathode was kept constantly moved about in the solution, while the current was passing, the deposit assumed the characteristic appearance of gold, but not of a good colour.

2. *Iodide of Gold in Cyanide of Potassium.*—A quantity of moist protiodide of gold, prepared as above, was next dissolved in a moderately strong solution of good cyanide of potassium, and the solution after being filtered was diluted with about four volumes of distilled water. With the current from two Daniells, gold of a deep yellow colour deposited somewhat slowly upon a silver plate. The solution was next heated to about 100deg. F., when a fresh silver plate was immersed, which became instantly coated with gold of a fine deep yellow colour much resembling jewellers' "wet colour" gold in tone. With three cells, and the cathode kept briskly in motion, a very rich and bright deposit was obtained.

3. *Gold Protiodide in Sulphocyanide of Potassium.*—Moist iodide of gold was digested in a moderately strong solution of sulphocyanide of potassium, and after filtering and diluting with about three volumes of water the solution was tried with the current from two cells, when gold of a deep yellow colour formed upon a silver plate. A similar result was obtained when the solution was warmed, but the cathode required to be kept gently in motion to ensure a uniform film, when the metal deposited was of a very fine colour.

4. *Sulphocyanide of Gold by Electrolysis.*—A rather strong solution of sulphocyanide of potassium was electrolysed with the current from four Daniells in series, a gold anode and silver cathode being used as the electrodes. The action was somewhat slow, but in the course of a quarter of an hour or so a slight film of gold formed upon the silver plate, which assumed an indifferent colour as the deposit became thicker. An improvement, however, took place when the solution was warmed and the cathode kept gently in motion.

5. *Auroteriodide of Gold and Potassium.*—A solution was prepared by gradually adding a neutral solution of terchloride of gold to one of iodide of potassium, and the dark green solution formed was then diluted with water and electrolysed with the current from three cells. A deposit of gold, of a somewhat indifferent colour, slowly formed upon a silver cathode, and the anode was coated with a film of iodine; when this film was rubbed with the finger and white paper smeared with it, an intense blue colour immediately appeared, which was due to the formation of iodide of starch, the latter substance being used as a stiffening material in the manufacture of paper.

5. *Teriodide of Gold in Cyanide of Potassium.*—As in experiments 2 and 3, the present combination was devised in the hope that a solution would be obtained which would yield deposits of gold of good colour without heating the solution. A quantity of teriodide of gold being prepared by gradually adding a solution of the terchloride of gold to one of iodide of potassium, a strong solution of cyanide was then added, and the resulting liquid, after filtration and dilution with about four volumes of water, was electrolysed with the current from two Daniells in series, a silver cathode being used as before. The solution was at first used in its cold state, when a film of gold of a good rich colour was obtained. A third cell was next put into circuit, and the silver plate kept gently in motion, under which condition gold of a good deep tone of colour was obtained which fully equalled in appearance the gilding produced in warm cyanide solutions. A gilding bath of the composition given might be found useful in the plater's workshop.

6. *Gold Protiodide in Hyposulphite of Soda.*—A solution was prepared by dissolving recently precipitated and moist protiodide of gold in a strong solution of hyposulphite of soda, and the solution was then moderately diluted with water, and the cold solution then electrolysed with the current from two cells. A deposit of gold, of good colour, soon formed upon the silver plate, and much resembled in tone the deposits obtained in warm cyanide baths.

7. *Auroterfluoride of Potassium by Electrolysis.*—A strong solution of fluoride of potassium was electrolysed with the current from three Daniells in series; gas was freely liberated at both electrodes, and in about 15 minutes after immersion of the plates a deposit of gold began slowly to form upon the silver cathode. On examining the anode it was found that a dark orange-coloured film had formed on the immersed portion of the plate, which strongly emitted the vapour of fluorine.

8. *Auroterbromide of Potassium by Electrolysis.*—A solution of bromide of potassium was prepared by dissolving 60 grains of the salt in one ounce of distilled water. A gold anode and platinum cathode, connected with three Daniells, were then immersed in the liquid, when it was noticed that gas was freely given off at each electrode, and that a deep orange-coloured and very dense solution of terbromide of gold formed at the anode, and flowed from the plate in a continuous stream, causing the liquid to assume at first a pale yellow, and after a time a deep orange colour similar to the analogous chlorine, salt of gold. In the course of two or three minutes from the commencement, a film of gold appeared on the surface of the platinum plate, but a few minutes after the deposit acquired the dark green non-reguline character, which this metal often assumes when deposited from some of its solutions by electrolysis, and indeed, not unfrequently when precipitated from some of its solutions by chemical reaction. Respecting this green form of gold, to which reference may have to be made somewhat frequently, it is clear that although its colour and non-metallic appearance give no indication of its real metallic character, that it is, in fact, metallic gold in a highly comminuted condition, and in this state bears a close resemblance to a form of iron which the writer has frequently obtained when electrolysing solutions of persalts of that metal. The electrodes were next left undisturbed in the bath, under the action of the same current, for about four or five hours, at the end of which time it was found that a profuse spongy mass of gold had formed at the cathode and spread out until it reached the anode, when, of course, the current was stopped—the spongy mass, which was of a nut-brown colour, similar to the gold obtained in making a parting assay of the metal. Finding the solution to be too strong in metal for a gold bath, it was next diluted with about three volumes of water and was tried again with the same current as before, when a silver cathode became coated with a film of gold a few seconds after immersion, but the colour of the deposit varied considerably during the immersion of the plate. Although gilding of a very fair colour may be obtained from this solution, with care, there is some uncertainty as to the working of baths prepared with this salt, and it cannot on this account be recommended as a reliable material for making up gilding solutions to be used for practical purposes.

9. *Auroteriodide of Potassium by Electrolysis.*—A moderately strong solution of iodide of potassium was electrolysed with the current from three cells in series, a gold anode and silver cathode being immersed in the liquid. The electrolytic action was very prompt, the solution nearest the anode assuming a deep orange colour almost immediately, causing the bulk of the liquid to acquire a pale yellow colour, which deepened into a full orange tint in a very short time. In about 15 minutes from the commencement, the silver cathode was found to be coated with a film of gold of a good colour. It may be said that in nearly all respects the results obtained in this experiment resembled the preceding, except that of the two solutions the latter yielded the better coloured deposit.

10. *Auroterbromide of Ammonium by Electrolysis.*—A solution of bromide of ammonium being prepared, this was electrolysed with the current from two cells in series, when it was found that the anode, as before, became rapidly dissolved, and an orange-yellow solution produced, at which point the silver cathode began slowly to receive a coating of gold, which deepened in colour as the deposit thickened. In all respects, however, the results obtained

in this experiment closely resembled those noted in experiment 8.

11. *Aurochloride of Ammonium by Electrolysis.*—A strong solution of chloride of ammonium was electrolysed with the current from three cells, when it was found that a light brown powder of fulminate of gold formed at the anode and accumulated at the bottom of the vessel. In less than half a minute from the commencement a film of gold appeared upon the silver cathode, but in about one minute after the deposit appeared of a dense black colour. The solution was next diluted considerably, and a freshly-prepared silver plate immersed, when the deposit became more reguline, but iridescent in parts. The current was now reduced by disconnecting two of the cells, when the metal deposited in a much better condition. The solution being a very good conductor, the current from one cell was found to be fully sufficient for the reduction of the metal, a very small anode surface being also necessary to secure a good-coloured film.

(To be continued.)

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

I.—INTRODUCTORY.

It is only within the last few years that in this country the twin subjects of Electricity and Magnetism have been really promoted to the dignity of a science. Formerly the crude results obtained from electrical and magnetic experiments were to a great extent dependent upon a rude system of arbitrary and ill-defined units, which, being but imperfectly understood, were often the cause of much perplexity to the uninitiated investigator. As a result of the brilliant labours of the British Association's Electrical Standards Committee, a rational set of units was at length elaborated, and this had the effect of placing electrical investigation on a firm and sound basis. The former chaotic state of electrical nomenclature, and its correspondingly complicated system of measurement, have now passed away, and electricity, freed from the trammels which for so many years have hampered and impeded its progress, has at length entered into the region of an exact science. With our modern system of standards and units, differences of potential or electrical pressure, rate of flow or density of current, resistance to flow of current, and work performed in overcoming this resistance, may now be stated with the utmost degree of precision.

Coincident with this precise definition of the electrical units, appliances of great delicacy were constructed for their practical realisation and reproduction, and at the present time copies of all the standard electrical units may be obtained at a comparatively low cost, and of even greater accuracy than the units of mass or dimensions.

Within the last few years enormous strides have been made in the production of sensitive and reliable electricity-measuring instruments. The antiquated and troublesome galvanometers on the sine and tangent systems are rapidly being superseded by the more convenient direct-reading, and in many cases dead-beat, instruments. By the employment of simple and easily-managed current and potential measurers, the merest electrical tyro is now enabled to read off at a glance the amount of current and electrical pressure being developed by a dynamo, or the energy being consumed by one or more lamps, and to tell, by a simple arithmetical calculation, the amount of electrical energy stored in an accumulator, or involved in the transformation of a current of high intensity into one of lower and more useful electromotive force.

The aim of these articles is to describe the theoretical considerations involved in the construction of the various electricity measuring instruments, the methods employed in their manufacture, and their commercial applications.

We hold that an electrical engineer who thoroughly understands the construction of the apparatus he is using is far more likely to detect and localise any errors arising from imperfect workmanship or bad design than one who merely takes everything for granted, and who relies absolutely for his results upon a given constant or a table of equivalents. This applies to the use not only of commercial instruments, but also to those employed for purposes of calibration, and to standards.

We shall begin by defining and explaining the most commonly used electrical units, and their practical realisation and reproduction; and shall then go on to describe the various instruments to be obtained for measurements in terms of these units. Considerable attention will be devoted to the technicalities of construction of these instruments, and to the different characteristics which must be kept in view when it has been decided whether they are intended for measuring direct or alternate currents, or both. The various methods of calibration will be considered, and some special attention will be bestowed on the standardisation and re-calibration of standard instruments.

We will divide the subject of Electricity-Measuring Instruments into the different classes under which the instruments seem naturally to arrange themselves. Thus, in the first place, we have the two great classes — Non-Recording and Recording Instruments. These again subdivide into—Resistance, Potential, Current, Energy, and Capacity Measurers; and these still further into—Instruments for Direct Currents, for Alternate Currents, and for both.

In our treatment of the subject we shall endeavour, as far as possible, to confine ourselves to the essential and desirable characteristics of good and theoretically sound instruments, leaving the consideration of highly-polished metal work and æsthetically-designed outside cases—too often, alas! the only recommendation which certain classes of instruments possess—to take care of itself.

UNITS.

The three principal units used in electrical measurements are the *Ohm*, the unit of Resistance; the *Volt*, the unit of Electromotive Force; and the *Ampere*, the unit of Current; and to these may be added the *Watt*, the unit of Power or Rate of doing Work. Other units not so commonly in use are the *Coulomb*, the unit of Quantity; and the *Farad*, the unit of Electrostatic Capacity. The *Coulomb* was formerly termed the *Weber*, and in the Indian Telegraph Department the Ampere used to be known as the *Œrstedt*.

Ohm.—The unit of Electrical Resistance, the *Ohm*, is usually defined as the resistance offered by a column of pure mercury of a given section and length, and at a certain fixed temperature, to the flow of an electrical current. Unfortunately some little difficulty has arisen in assigning a definite value to the unit of Resistance, and many suggestions have been made as to what the real value of the Ohm should be. From these may be cited the Siemens Ohm, the British Association Ohm (usually written the B.A. Ohm), the Kohlrausch Ohm, the Legal Ohm, the True or Rayleigh Ohm, and the Ohm proposed by Messrs. Duncan, Wilkes, and Hutchinson, as the result of an investigation made at the Johns Hopkins University, Baltimore, U.S.A. The British Association Ohm, however, is now the one generally adopted, and, in this country at least, when the term "Ohm" is used without qualification, the B.A. Ohm is always understood.

In the second column of the following table are given the various lengths of a uniform column of pure mercury of one square millimetre in sectional area and at a temperature of 0deg. centigrade, whose electrical resistances are stated as representing the respective values of the Ohm, and in the three succeeding columns these values are given expressed in terms of (3) the B.A. Ohm; (4) the Legal Ohm; and (5) the True Ohm.

TABLE I.—RELATIVE VALUES OF THE VARIOUS "OHMS."

Description of "Ohm."	Length of mercury column 1 sq. mm. section and at 0° C.	Values expressed in terms of		
		B.A. Ohm.	Legal Ohm.	True Ohm.
	Centimetres			
Siemens Ohm	100·00	0·9541	0·9435	0·9411
B.A. Ohm	**104·82**	**1·0000**	**0·9889**	**0·9864**
Kohlrausch Ohm ...	104·93	1·0010	0·9899	0·9874
Legal Ohm	106·00	1·0113	1·0000	0·9975
True Ohm..............	106·27	1·0139	1·0026	1·0000
"Baltimore" Ohm..	106·34	1·0146	1·0033	1·0016

(To be continued.)

NEW ELECTRIC RAILWAYS FOR LONDON.

The comparative success of the existing electric railway in London has evidently given an impetus to the movement for providing still further means of locomotion of a similar kind. For consideration during the forthcoming session of Parliament there are no fewer than five Bills which propose either the construction of new electric railways or the extension of lines already authorised.

Great Northern and City Railway.

Among the most important of these is the Great Northern and City Railway Bill, which is a proposal for the incorporation of a new company with powers to construct a line of railway from the Canonbury branch of the Great Northern line near Finsbury Park to the City. The capital of the proposed company is fixed at £1,500,000, in shares of £10 each, and the works which it is proposed to execute are (1) a railway five furlongs 5·70 chains in length in the parish of St. Mary, Islington, commencing by a junction with the up-line of the Finsbury Park and Canonbury branch of the Great Northern Railway and terminating at Drayton-park, Holloway; (2) a railway one furlong one chain in length commencing by a junction with the down-line of the Great Northern Railway and terminating at the same point as Railway No. 1; (3) a railway two miles five furlongs 1·40 chains in length, commencing by a junction with the terminus of Nos. 1 and 2 railways and terminating in the parish of St. Stephen, Coleman-street, at Finsbury-pavement, opposite the north side of West-street. The method of construction proposed is similar to that adopted on the City and South London line, the greater portion being constructed in two tunnels for separate up and down traffic. The railway will be approached by means of stairs or inclines, and hydraulic or other lifts. The tunnels are to be constructed by means of steel or other sufficient metal shields, driven forward by hydraulic pressure as the work proceeds, the shields being of sufficient length to protect the whole of the soil for a reasonable distance both in front and behind the working faces. The Bill provides that the exits and entrances of the station buildings and the waiting accommodation for passengers shall be so designed and of such an extent as to secure the least practicable inconvenience to the public traffic in the adjoining streets, and plans of the stations outside the City are to be submitted to the London County Council. The period for the completion of the works is limited to five years, and provision is made for cheap fares for the labouring classes, the proposal being to run two trains each morning and evening at fares not exceeding a penny for each journey. Power is given to enter into an arrangement with the Great Northern Company to construct the line.

Islington and the City.

The City and South London Railway Company have brought in a Bill repeating their proposal of last year for the construction of a line extending their system to The Angel, at Islington. Last session the Bill was thrown out mainly because of the fact that no physical junction was provided in the City with the existing line. It is now proposed to construct a line from near the St. George's Church, in the Borough, to the northern end of the City-road, Islington, near The Angel—a distance of two miles five furlongs three chains and 50 links—and, in addition, two subways for foot passengers; the first, under the High-street, Borough, to afford an access from the underground electric railway to the London and Brighton and South-Eastern Railway stations at London Bridge; the other, under Arthur-street East, which will give access to the present electric railway at its terminus at Fish-street-hill. The mode of construction is the same as that described above, and the period named for the completion of the works is five years. Provision is made for agreements with the Metropolitan, the Metropolitan District, the Joint Committee of those railways, the London, Brighton, and South Coast, the Great Northern, and the Central London Railway for the purposes of construction, working, traffic, etc., and the City and South London Company is to be authorised to raise an additional capital of £810,000, with further borrowing powers of £270,000.

Central London Railway.

The Central London Railway Company, who were empowered last session to construct a line from Shepherd's Bush to the City, are proposing this session to extend their powers by the making of a line from under Mansion House-street, near the junction with Queen Victoria-street, to the Liverpool-street Station of the Great Eastern Railway Company. In respect of this scheme they propose to raise an additional capital not exceeding £150,000, in shares of £10 each, and to take additional borrowing powers to the extent of £50,000. The time proposed for the carrying out of the work is limited to five years, and the rates and charges are to be the same as were authorised in the Act of last session. Power is proposed to be taken to enter into agreements with the Great Eastern Railway Company, the London and North-Western Railway Company, the North London Railway Company, and the Metropolitan Railway Company for the interchange, transmission, and delivery of traffic on the respective railways, as well as for the construction, use, management, and maintenance of the stations, subways, lifts, etc., of the company.

Baker-street and Waterloo.

There are no less than three new railways projected from and to Waterloo, one of which is an underground railway to be worked by electricity, commencing at the western end of New-street, Upper Baker-street, in the vicinity of Dorset-square, running thence by the southern end of Langham-place at its junction with Regent-street, the Quadrant in Regent-street, opposite the County Fire Office, to James-street, Lambeth, about 90 yards from its junction with Lower-marsh. The first directors of the new company would be Colonel the Hon. Henry Walter Campbell, Major-General Charles Taylor Du Plat, Colonel Ambrose Humphrys Bircham, Lieutenant-Colonel Francis Douglas Grey, Mr. Arthur Ralph Ricardo, and one other person to be nominated by the foregoing. The capital would be £1,250,000, consisting of 125,000 £10 shares, with power to subdivide the same into preferred and deferred half shares. It is sought to enter into working agreements with the Metropolitan, South-Eastern, Metropolitan District, Central London, and London and South-Western Railway Companies. Cheap fares, not exceeding 1d. for each journey, would be charged to the labouring classes up to seven o'clock in the morning and after six o'clock in the evening. The Bill also contains clauses saving the rights of the Crown, the Thames Conservancy, under whose direction the works under the Thames would be executed, and the London County Council, and general provisions for the protection of water, gas, hydraulic power, and electric companies; and the time fixed for the completion of the works is five years.

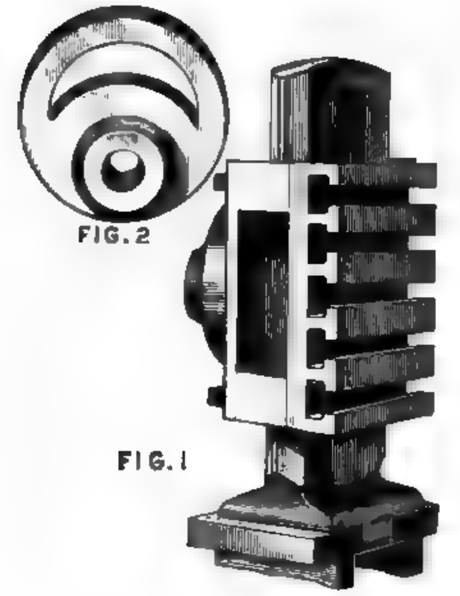
Royal Exchange and Waterloo.

In addition to the intended Waterloo and City Electric Railway, it is also proposed to extend the London and South-Western and London, Brighton, and South Coast Railways to a terminus in the City, for which purpose it is sought to incorporate a new company, consisting, among others, of the Hon. F. S. A. Hanbury-Tracy, Major John Eustace Jameson, Mr. Campbell Praed, and Mr. James Cholmeley Russell, with a capital of £2,700,000, divided into 270,000 £10 shares. Junctions would be formed with the main, Windsor, and other lines of the London and South-Western Company at Waterloo Station, and with the London, Brighton, and South Coast Railway in the parish of St. John, Horseleydown, where it crosses Bermondsey-street by means of a bridge; and the new lines would run by way of Southwark-street to a point in the City close to the junction of Crooked-lane with Arthur-street, crossing the Thames by means of a bridge, in connection with which a free public footway would be constructed. Three years is the time fixed for the compulsory acquirement of land, and five years for the completion of the works. It is also sought to enter into working agreements with the London and South-Western and the London, Brighton, and South Coast Companies, and to pay interest out of capital during construction.

TRADE NOTES—ELECTRICAL AND MECHANICAL.

LATHE ATTACHMENT.

A modified form of shaping attachment is shown in our illustration, designed by Mr. F. M. Rogers, of 21, Finsbury-pavement, E.C., to meet the demand for a tool of this class capable of working on light-built single-geared treadle lathes, such as are used by amateurs and other light metal-workers. The stroke is fixed, and is determined by the throw of the eccentric sheave, shown in Fig. 2, which is screwed direct to the nose of the mandrel, and travels in the grooved path upon the sliding face-plate, thereby imparting a noiseless reciprocating motion to it. The stroke in the size shown, which is that adapted to a 4in. centre lathe, is about 2in., which enables as many as 120 strokes per minute to be taken with ease in soft metal, such as brass or gunmetal.



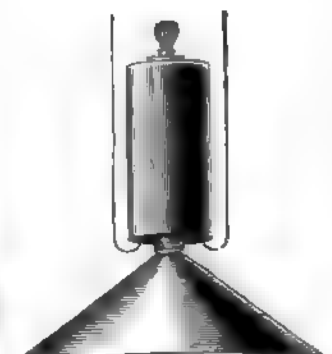
New Form of Lathe Attachment.

The V-shaped packing blocks are of gunmetal, and an adjustment is provided for taking up wear. When fitted with a parallel vice, this little tool will rapidly shape odd pieces of metal which would otherwise have to be filed up. Larger work is bolted to the grooved face-plate. The slide rest is operated by hand or by a self-acting motion. The price, which is moderate, should place it within the reach of every metal-worker.

A NEW FORM OF ELECTRIC MEASURING INSTRUMENT

The accompanying illustration shows an electrostatic instrument recently brought out by Messrs. Swinburne

Swinburne's Electrostatic Instrument.



2,000-Volt Street Lamp with Transformer.

and Co. for experimental work in connection with alternate currents. Instead of quadrants there are two pair of half discs, so that the angle of deflection can be large. The needle consists of two half discs fastened on a metallic arbor. It is held by top and bottom metallic suspensions. One disc is in the upper box and the other in the lower. The boxes are connected, not to ordinary terminals, but to highly-insulated flexibles; as the ordinary terminals are not suitable for high pressures. The instrument can be used as a voltmeter; or it may be connected up to measure power by any of the various methods involving two readings. It can also be connected up as a direct-reading wattmeter. The electromagnet below the boxes acts on a copper drum, and renders the instrument dead-beat. This magnet is excited by a cell. For large readings the torsion head and pointer on top of the instrument are used, but for small readings the mirror is employed. Four of these instruments have been lent to Dr. Fleming to carry out experiments on the measurement of power by various different methods.

A TWO THOUSAND-VOLT STREET LAMP.

Street lighting by alternate currents has for some time past presented considerable difficulties. In most cases transformers are arranged in the houses, and the stations have high-pressure leads only. To run incandescent lamps it is therefore necessary to employ transformers and a system of low-pressure leads. Messrs. Swinburne and Co. have brought out a lamp which contains a small transformer, and is connected direct to the high-pressure system without any low-pressure leads. A 32-c.p. lamp, with protector, is arranged under a large enamelled iron shade, which is secured to the base case of a small transformer. The efficiency of the transformer is high, considering how small it is, being, according to the makers, just under 90 per cent.

COMPANIES' MEETINGS.

ELMORE'S WIRE MANUFACTURING COMPANY, LIMITED.

Directors: J. Jepson Atkinson, Esq.; Edward J. Carson, Esq.; John T. Cooper, Esq.; John Macfarlan, Esq.; Sir John H. Morris, K.C.S.I.; William Elmore, Esq. (managing director). Secretary: Mr. J. Shurmer.

Report of the Directors presented at the first ordinary general meeting of the Company, held at the Cannon-street Hotel, E.C., on Wednesday last.

The Directors have the pleasure to submit their report, and the accompanying statement of the Company's audited accounts, for the period commencing with the incorporation of the Company on March 15, 1890, and ending on October 31, 1891. The period in question has been devoted entirely to the erection of the Company's works upon 13 acres of freehold land purchased from the parent company, and immediately adjoining that company's works. The main building consists of a series of bays, each 400ft. long by 35ft. wide, having a total width of 350ft., under one roof, and covering a space of about 3½ acres. These buildings have been designed with a view to an output of 140 tons per week. There are also offices for the staff and Managing Director complete in every respect, together with convenient store and packing-shed, with sidings from the Midland and Great Northern Railways already connected up therewith. The actual progress made at the works, as reported by the Managing Director, is as follows: Buildings, comprising shop, engine-house, depositing-sheds, boiler-house, dynamo and engine house, and machine shop, for an output of 140 tons per week; chimney shaft, 240ft. high, for 280 tons; railway sidings; overhead cranes throughout, and melting furnaces and flues for 140 tons; boilers, generating engines, dynamos, and electrical switches for 44 tons; fuel economisers, tanks, and tank gearing for 35 tons; engine and dynamo for the electric lighting of the whole works inside and out; shop engine, shafting, and additional gearing; slitting, flattening, straitening, and other machinery for 70 tons a week. From this enumeration it will be seen that the works will make a start with an output of about 35 tons a week. This can be readily increased up to 70 tons a week with little additional expenditure above that already incurred. The Company has also acquired from the parent company, upon a moderate royalty, the sole license outside the requirements of the parent company for the manufacture of copper sheet under a patent taken taken out by the parent company last year, and the Board consider, in view of the large demand for copper sheet, that this license will prove of great value. Since the Company was formed and the buildings commenced, the Directors have learned with satisfaction that the whole of the proposed output can be readily disposed of in the form of ribbon or tape, and planished sheet, at a profit considerably in excess of that estimated from the sale of wire spirals. The Company will therefore neither erect wire-drawing plant on a large scale for the present, nor dispose of its copper spirals to wire-drawers, thus adding to the gross earnings of the Company one manufacturing profit. Mr. Elmore, managing director, reports that early in the

year 1892 the Company will be in a position to commence with an output of 35 tons per week. In regard to the accounts, these are exceedingly simple; inasmuch as no trading account having yet been opened, the only outgoings beyond capital expenditure are those occurring under administration expenses, which, however, have been reduced by one-half, largely in consequence of the satisfactory profit derived from a judicious investment last year in Consols and Bank of England stock. The auditors, Messrs. Deloitte, Dever, Griffith, and Co., offer themselves for re-election, and the Directors recommend a payment to them of 35 guineas for their services.

BALANCE-SHEET, 31ST OCTOBER, 1891.

Dr.		£ s. d.	£ s. d.
Nominal capital—			
150,000 ordinary shares of £2 each		300,000 0 0	
10 founders' shares of £2 each		20 0 0	
		300,020 0 0	
Share capital issued—			
67,385 ordinary shares of £2 each		134,770 0 0	
1,360 less shares forfeited		2,720 0 0	
66,025		132,050 0 0	
Less calls in arrear		12,751 5 0	
		119,298 15 0	
Add amount received on forfeited shares		390 0 0	
		119,688 15 0	
10 founders' shares of £2 each		20 0 0	
			119,708 15 0
Premium on shares issued—			
£1 per share on 66,025 shares		66,025 0 0	
Less in arrear		3,240 0 0	
		62,785 0 0	
Add premiums received in respect of forfeited shares		62 10 0	
		62,847 10 0	
Of which one-half credited to vendors in part consideration of purchase price			31,423 15 0
Reserve fund—one-half of premiums received to date			31,423 15 0
Sundry creditors			8,301 19 11
			£190,858 4 11

Cr.			£ s. d.
Cost of licenses			111,505 0 0
Cost of land at Leeds			13,000 0 0
Investment account			8,200 0 0
Buildings		£25,891 5 6	
Plant and machinery		15,391 5 9	
			41,282 11 3
Stock of raw copper			5,314 17 10
Furniture, fixtures, and fittings			329 14 10
Administration expenses, viz.:			
Rents, rates, and insurance		£427 18 8	
Stationery, printing, and advertising		210 3 10	
Travelling expenses		78 6 11	
Law charges, etc.		190 8 3	
Carriage		102 7 6	
Salaries		1,812 6 0	
Directors' fees to Sept. 30, 1891		2,250 0 0	
Office expenses, postages, etc.		196 14 3	
			5,268 5 5
Less:			
Interest and discount received	£1,725 3 5		
Profits on investments	891 18 7		
Transfer fees	76 18 6		
		2,694 0 6	
			2,574 4 11
Sundry debtors			485 6 5
Cash at bankers and in hand:			
In London		7,315 17 10	
At Leeds		850 11 10	
			8,166 9 8
			£190,858 4 11

The first annual ordinary general meeting of the shareholders of Elmore's Wire Manufacturing Company, Limited, was held on Wednesday at the Cannon-street Hotel, under the presidency of Mr. J. Jepson Atkinson.

The **Secretary** (Mr. J. Shurmer) having read the notice convening the meeting,

The **Chairman** said: Gentlemen, the report speaks for itself, and is so exceedingly simple that in addressing you I can have very little to say. What will strike you first is that a company calling itself a wire manufacturing company should propose to you, its shareholders, after you have subscribed your capital, not even to put down plant to draw wire at all. This admits of an easy explanation. Gentlemen connected with the wire-drawing trade, and having large capital invested in drawing plant, approached us some time previous to your last general meeting, and having thoroughly tested the quality of the copper to be produced by us offered to take our entire output at a price which, while satisfying us, did not interfere with their own business of drawing. Your Directors considered that this arrangement was better than entering into competition with the whole trade. This was explained to you at the last general meeting. Since then we have ascertained the fact that by depositing our large copper tubes up to about ¼in. and over, and then cutting them up into a wide spiral of, say, 2in., which can be done very easily indeed, we have a form of copper-ribbon or tape used for electric lighting and transmission of power. While the demand for this copper-tape exceeds our entire output, the price is much in excess of the best price we could obtain for wire spirals such as the wire-drawers would have taken; so that, even before the whole of our works are complete, we shall have a better market for our produce than was contemplated when the prospectus was issued. The electric lighting of a town like Leeds would keep us busy for a length of time, and I am informed that for the electric lighting of London alone over 100,000 tons of this kind of strip will be used. A second very simple invention is likely to form an important source of revenue to us. It was found that by exposing the mandrel to the oxidising action of the atmosphere for a few minutes when a certain thickness of copper was deposited upon it, and then continuing the operation till a similar thickness of copper was deposited, and by a continual repetition of this process, a series of tubes could be formed entirely separate and distinct from one another. One cut down the length of these superimposed tubes gave, when opened out, a number of beautifully-burnished sheets of perfectly even surface and thickness, and equal in every way to those known in the trade as planished sheets. These, of the size furnished by us, cannot be procured at the present time in the market, and consequently they will command a high price. All I have to say in addition to this is that this meeting was put off to the last minute in the hope that I should be able to announce to you that the 35-ton plant was at work. The fog and the Christmas holidays have prevented it, but there is steam in our boilers and very little more to do at the plant, and we hope within three weeks or so to be at work. Our business being a mere repetition of the same process over and over again, and the fact that we have no customers to seek or market to create, make it evident that as soon as ever we get a start our dividend-earning will commence. Some of you have seen the works, and know from what you have seen that a great deal has been done, and the drawing on the table will give those who have not been down an idea of the size of our premises, which, I am told, comprise the largest shed in Yorkshire. To give you an idea of how large a place it is, I may say that I took the managing director of the largest coal company in the North of England to see Mr. Elmore, and as we walked through the buildings he said to me: "I suppose you are going to employ 5,000 hands here." I took him to Mr. Elmore, who, after showing the labour-saving apparatus and the process, was able to tell him that we should not employ 5,000, or 1,000, or even 100 hands, but less than 30. That will give you some idea of the advantages of the process. I have nothing further to say to you, gentlemen; but Mr. Elmore or I will be very glad to answer any questions that may be put to us.

Mr. William Elmore (managing director): The drawings on the table will give you some idea of the magnitude of the building and of the operations carried on. We have one building which will cover something like 3½ acres under one roof—one of the most magnificent buildings in Yorkshire. It is all complete now, and one-third of the plant will certainly be ready for operation in the course of a fortnight; that is equal to 35 tons per week. I may say that we have been impeded very much indeed by the very serious delays of the various contractors who are supplying the manufacturing plant and some of the buildings. The contractors who put the roof on the large building to which I have just referred were something like five months behind with their contract; but everything about the building is now completed, and the plant is capable of turning out 35 tons per week. We have got steam in the boilers now, and the engines are actually working, therefore there is not the slightest doubt that in a fortnight from now we shall be commencing the output I have mentioned. As soon as the first 35-ton plant is in operation we shall commence upon the next portion of 35 tons, and so on until we fill the whole of this building, which is capable of an output of 140 tons per week. There is a demand upon us even at the present moment for far more than we can produce, which is exceedingly satisfactory, and at a very handsome price, which will leave a very large profit. I shall be very glad to answer any questions any gentleman may wish to put.

Mr. Guarracino said Mr. Elmore had stated that with the present plant there would be an output of 35 tons per week. He wished to ask if it was simply a question of multiplying the tanks, etc., to increase the output to 140 tons, or whether they would require further motive power.

Mr. Elmore, in reply, said this was fully explained in the report. Buildings, comprising shop, engine-house, depositing-sheds, boiler-house, dynamo and engine house, and machine shop, had been completed for an output of 140 tons per week. The chimney shaft, which was 240ft. high (a magnificent piece of work), was good for an output of 280 tons. The railway sidings on the Midland and Great Northern Railways had been completed. The overhead cranes had also been completed, as well as the melting furnaces and flues for 140 tons; the boilers, generating engines, dynamos, and electrical switches for 44 tons, and the fuel economisers, tanks, and tank gearing for 35 tons. The engine

and dynamo for the electric lighting of the whole works, inside and out, had likewise been completed, and also the shop engine, shafting, and additional gearing and slitting, flattening, straightening, and other machinery for 70 tons a week. Therefore, with very little additional expense they would have an output of 70 tons per week, but they intended to commence with 35 tons.

The **Chairman** then moved: "That the Directors' report and statement of accounts for the period ending October 31 last be passed and adopted."

Mr. Edward J. Carson seconded the resolution, which was put and carried unanimously.

Mr. Scrutton proposed the re-election of Messrs. Deloitte, Dever, Griffiths, and Co., as auditors for the ensuing year.

Mr. White seconded the motion, which was agreed to.

Mr. Blumer moved: "That the best thanks of the meeting be given to the Chairman for presiding on this occasion, and also to the Directors and officers for their efficient management of the affairs of the Company."

This was seconded by **Mr. White**, and passed with acclamation.

Mr. Guarracino said he did not think the shareholders should separate without according a special vote of thanks to Mr. William Elmore.

Mr. John T. Cooper seconded the resolution, which was adopted.

Mr. Elmore, in acknowledging the compliment, expressed the hope that no effort on his part would be wanting to make the business a thorough success, as he intended it should be.

The proceedings then terminated.

ELMORE'S PATENT COPPER DEPOSITING COMPANY, LIMITED.

Directors: J. Jepson Atkinson, Esq.; Edward J. Carson, Esq.; John T. Cooper, Esq.; G. C. V. Holmes, Esq.; John Macfarlan, Esq.; Sir John H. Morris, K.C.S.I; Frederick L. Rawson, Esq., M.I.E.E.; William Elmore, Esq. (managing director). Secretary: Mr. J. Shurmer.

Report of the Directors presented to the second ordinary general meeting of the Company, held at the Cannon-street Hotel on Wednesday last.

Your Directors have pleasure in submitting to the shareholders their report, and in congratulating them on the satisfactory technical and commercial prospects of the Company. They also submit the accompanying statement of the accounts for the year ending June 30th, 1891, which shows a credit balance at the end of the preceding year of £77,825. 1s. 4d, from which two dividends of 10s. each, making £1 on each £2 share, were paid. It will be seen that the accounts show credit balances on the 30th June last of £14,261. 17s. 10d., made up of £5,000 royalties on copper sheets received in advance, £8,558. 7s. premiums and profit on land, and balance of profit and loss of £703. 10s. 10d., a satisfactory result considering that the Company had only been able to manufacture small quantities of articles at the date of the making up of the accounts—work on a large commercial scale not having been then commenced. The Directors have much satisfaction in announcing the successful completion of the 20-ton plant, and thus the programme of work set forth in the prospectus has been carried out. The cost of manufacture has also now been found to be only about ½d. per pound weight of finished goods (see report below)—that is to say, about one-half the cost that the Directors estimated in the prospectus—whilst the statements as to the technical features of the process have been entirely proved. The Directors are the more gratified in being able to refer to these results, as, though the application of the essential part of the Messrs. Elmore's invention has remained unchanged, various difficulties connected with the mechanical details of the process, inseparable from the commercial development of all important inventions, were encountered. These caused some considerable delay. The Managing Director reports that all these difficulties have now not only been successfully overcome, but that they have led to the taking out of additional patents of great value, which will have the important practical effect of prolonging the monopoly of the invention. Foremost amongst these may be mentioned the patent for the manufacture of sheet copper, the license to work which on a royalty, which will prove a valuable source of income to this Company, has been granted to Elmore's Wire Manufacturing Company. The Directors desire specially to draw the attention of the shareholders to the purchase of the Haigh Park Estate, Leeds, consisting of 127 acres of freehold land, on a portion of which site the Company's works have been erected. The purchase of this property was rendered advisable by the impossibility of acquiring portions of it required for the purposes of the Company and its future extensions, except at the price of £2,000 per acre, whereas the price actually paid for the whole estate was only £534 per acre, including all expenses. The land is within half a mile of the borough of Leeds, connected by sidings with the Midland and Great Northern Railways, and has a wharf on the Aire and Calder Canal, which latter bounds the estate for three-quarters of a mile. It has an extensive frontage to the Pontefract high road, and is in close proximity to cheap coal supplies. The new line of the South Leeds Junction Railway, for which a Bill has been lodged in Parliament, is planned to run through the estate. These advantages and improvements have resulted in what the Directors foresaw—viz., a great increase in the value of the land, which must make the purchase a valuable acquisition for the Company. Negotiations have already taken place for the sale of portions at a considerably higher price than that paid. A plot of 13 acres has been disposed of at £1,000 per acre to Elmore's Wire Company, and this price, whilst yielding an excellent profit to your Company, is nevertheless 50 per cent. below the price demanded for this plot by the former owner, and the Directors are advised that they will be enabled to dispose of the whole of the land not required for the purposes of the Company at a similar profit. The completion of the 20-ton plant was lately marked by an invitation to the larger shareholders to see it at work, and over 100, from various parts of the country, availed themselves of this invitation, and they expressed the greatest satisfaction at what they saw. The Messrs. Elmore have made a joint report to the Board as to the earning powers of the works. This report is of a most important character and is enclosed herewith. By this report it will be seen that the profits of the works as now completed are put at over £45,000 per annum, being 30 per cent. upon the present capital of the Company, whilst when the time comes for doubling the output to 40 tons per week the profits will be increased to over £95,000 per annum, equal to nearly 50 per cent. upon the increased capital that will then be required. These returns, extraordinary as they may seem, Mr. Elmore fully believes will be exceeded by actual results; and considering that the report takes no account of important sources of profit, such as sales of licenses, recovery of precious metals, and special kinds of work, the Directors see no reason to doubt the conc usions therein contained. From the numerous testimonials from important firms, copies of some of which have already been despatched to the shareholders, it has been shown that the goods supplied to customers have given complete satisfaction, and of this the numerous repeat orders, and the offers of a very large additional business at remunerative prices, are a still better and more practical proof. The Directors desire, in conclusion, to record their belief that now that the Company may be considered to have entered upon its legitimate manufacturing business on a commercial scale, the shareholders will find that in the Elmore invention they possess a process that will be a continued source of profit, increasing from year to year, as the quality of the goods produced becomes more and more known. The Directors who retire are Sir John Morris, Mr. Atkinson, and Mr. Carson; the former, owing to ill-health, does not seek re-election; the latter two are eligible and offer themselves for re-election. The auditors, Messrs. Price, Waterhouse, and Co., also retire and offer themselves for re-election.

Since the Directors' report was made out, the result has been received from Leeds of an important competitive trial that has just taken place of an Elmore tube 9in. in diameter and ⅛in. thick against the best brazed tube obtainable, of similar size, made by the ordinary system. The tests showed that the brazed tube burst in an uneven manner at 448lb. pressure. The Elmore tube stood 1,456lb. pressure, being over three times as strong, and then gave way gradually and evenly. Some idea may be formed of the strength of the Elmore tube when it is mentioned that the testing machinery had to be specially prepared, owing to the enormous resisting power of the Elmore tubes.

Report of Managing Director.

To the Directors, Elmore's Patent Copper Depositing Company, Limited.

Pontefract-road, Leeds, Nov. 30th, 1891.

Gentlemen,—As requested, I beg to hand you my estimate of the approximate annual profits to be earned by the 20-ton per week plant, now complete and in operation at the above works, as follows:

Proceeds of 20 tons of copper tubes and other articles, per week, which, per annum (of 50 weeks) is 1,000 tons, equal to 2,240,000 pounds weight, at 1s. per pound ...		£112,000
(1s. 1¾d. per pound weight of copper being the average selling price calculated upon the total of the orders now on the Company's books being executed).		
It is important to note that for every 1d. per pound over 1s. added to the selling price of tubes manufactured by this Company, on a basis of 20 tons per week, over £9,000 per annum will be added to the profits.		
Less cost of production.		
Deduct cost of 1,081 tons rough copper bars, at £50 per ton (market price of Chili bar to-day is £44. 10s.)		54,050
		£57,950
*Coal consumed, 80 tons per week, say 4,000 tons for 50 weeks at 10s. per ton	£2,000	
*Labour £40 per week is per annum of 50 weeks...	2,000	
*Oil, chemicals, and sundries, say £10 per week, is per annum of 50 weeks	500	
*Contingencies, at £10 per week	500	
		5,000
		52,950
Allow for depreciation of plant		2,500
Net profit......		£50,450

*Equal to about ½d. per pound weight for cost of manufacture.

Upon the basis of actual cost at these works, and experience gained on the practical scale to date, I have added to every item from 25 per cent. to 50 per cent. for the purpose of meeting any contingency and being perfectly safe. You will be pleased to note that the cost of manufacture is about ½d. per pound, my original estimate being 1d. per pound. I have made a deduction for wear and depreciation at the rate of 50 per cent. of the total working expenses. Without taking credit for gold and silver recovered from the raw copper, or for the large extra profit to be derived from special kinds of work which the Company's process enables it to take at from 2s. 6d. to 5s. per pound (superseding hand labour at a much greater cost), the net profit equals over 33 per cent. on

£150,000, the issued capital of the Company. Owing to the high quality of the Company's manufactures, and the demand for them indicated by the largely-increasing number of applications for quotations and offers of work, it will be necessary to increase the existing plant, to double the present plant of 20 tons per week and make it equal to 40 tons per week.

The profits will then be, on the above basis, for 20-ton per week plant ...	£50,450
Add for double the production	50,450
	£100,900

There will be required for this extra production £20,000 for plant and £30,000 for working capital; this will make the total capital issued £200,000, on which, on the above basis of profit, the return would be over 50 per cent. per annum. Moreover, there is no reason for taking 40 tons per week as the limit of production. For instance, the French Elmore Company's works, which are nearly completed, are upon a scale of production of 80 to 100 tons per week, and the general manager, M. Secretan, writes that already he sees that the demand will enable the Company to double or even treble the plant within a short period. From the above facts it will be seen that in the Elmore invention the Company possesses a property not paralleled in the whole range of industrial investments, and now that the delay in getting the 20-ton per week plant at work—delay incidental to all new discoveries—has been overcome, the extraordinary earning power of the Company will be appreciated.—I am, Gentlemen, yours respectfully, William Elmore, Managing Director.

P.S.—I have not included in the above estimates the cost of the London and Leeds office expenses, salaries, and Directors' fees, amounting in all to, say, £5,000 per annum, although up to the present time these expenses have only slightly exceeded one-half that sum.

Balance-sheet, June 30, 1891.

Dr.	£ s. d.	£ s. d.
Nominal capital— 100,000 shares of £2 each	200,000 0 0	
Of which there have been issued 75,000 shares	150,000 0 0	
Less calls not yet due	6,500 0 0	
		143,500 0 0
Mortgages on land and interest to June 30, 1891		43,371 16 8
Sundry creditors		4,744 17 2
Royalties received in advance on copper sheet license	5,000 0 0	
Reserve account— Premiums received on new shares issued and £7. 10s. received on forfeited shares.	2,507 10 0	
Profit on 13 acres of land sold, being amount received after deducting proportion of cost of land and expenses, interest on original purchase-money and cost of mortgages	6,050 17 0	
Profit and loss—	8,558 7 0	
Balance as per account	703 10 10	
		9,261 17 10
		£205,878 11 8

Cr.	£ s. d.	£ s. d.
Purchase of 127 acres of land at Haigh Park, Leeds, including interest and costs	67,887 16 8	
Less proportion of cost and expenses of 13 acres sold	6,949 3 0	
		60,938 13 8
Buildings, sidings, and wharf, as at June 30, 1890	8,011 18 8	
Additions during the year ending June 30, 1891	3,512 16 10	
		11,524 15 6
Plant, machinery, etc., as at June 30, 1890	11,339 1 1	
Additions during the year ending 30th June, 1891	11,110 15 10	
		22,449 16 11
Patents as at 30th June, 1890	80,000 0 0	
Additions and expenses during the year ending 30th June, 1891	702 17 6	
		80,702 17 6
Sundry debtors	1,899 14 5	
Ordinary and founders' shares in Elmore's Wire Manufacturing Company, Limited, at cost	11,953 9 0	
		13,853 3 5
Stock in trade—viz.:		
Raw material	6,421 4 8	
Manufactured goods	803 2 9	
Sundry stores	582 13 1	
		7,807 0 6
Fixtures, furniture, and fittings		947 8 5
Cash at bankers and in hand		7,654 15 9
		£205,878 11 8

Profit and Loss Account for the Year ending 30th June, 1891.

Dr.	£ s. d.
Advertising and exhibition expenses	168 14 9
Travelling expenses and general charges	251 12 9
Rent, rates, and insurance	349 4 4
Balance of income tax	103 12 3
Stationery, printing, and postages	306 10 6
Maintenance of patents, legal and professional charges	358 14 9
Maintenance of plant and repairs	543 9 8
Directors' fees	1,452 19 6
Salaries	2,317 17 5
Balance carried to balance-sheet	703 10 10
	£6,556 6 9

Cr.	£ s. d.	£ s. d.
Balance, 30th June, 1890	77,825 1 4	
Less appropriated as under interim dividend of 10s. per share (less tax) paid April 18, 1890, £34,125; 2nd dividend of 10s. per share (less tax) paid July 29, 1890, £34,125; income tax on the latter, £875; preliminary expenses, £1,850; Directors' percentage of profits to 30th June, 1890, £3,930. 13s. 1d.	74,905 13 1	
		2,919 8 3
Balance of factory account, including amount received from Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited, for laboratory and experiment expenses		1,398 17 6
Sales of licenses		1,581 0 0
Interest and discount		417 14 7
Transfer fees, etc.		239 6 5
		£6,556 6 9

The second annual ordinary general meeting of Elmore's Patent Copper Depositing Company, Limited, took place on Wednesday at the Cannon-street Hotel, Mr. J. Jepson Atkinson presiding.

The **Secretary** (Mr. J. Shurmer) having read the notice calling the meeting,

The **Chairman** said: Gentlemen, there is an old saying, "Good wine needs no bush," and I think that after the report we have been able to send you you will not think it necessary for me to address you at any great length. You will see by the report that all the preliminary difficulties have been entirely overcome, and that we are now ready to go forward and earn money for you, and pay you handsome dividends. When we double, treble, and even quadruple our present plant, which we shall, in due course, have to do, those dividends will be so increased that I honestly believe you will have a chance of getting returns of cent. per cent. upon your investment in the capital of the Company. You will be glad to hear that our difficulty is not to take orders, but to know what orders to refuse out of the great number on offer. As you know, there is a French Elmore Company, formed to work the process in France, and last week I had the honour of being invited to see their works. These works are now in operation, and though designed for an output of 90 tons a week, already their manager reports that he can sell double their proposed output. From these remarks, and the figures which Mr. Elmore will give you, you will see there is not the slightest question about our getting a sufficiency of orders. I have no dividend to declare, but I can state to you, gentlemen, that we are to-day actually earning a considerable one—there is £500 profit in our tanks for this week—and I myself expect that before very long we shall be able to send each of you a nice little cheque as the result of what we are earning. I should like to say a few words about our investment in land, referred to in the report. As you are aware, we are not a land company, and in the ordinary course we should only have bought sufficient land for our own immediate requirements; but being myself an adjacent landowner, and knowing well its value in the neighbourhood of the rising town of Leeds, and finding that we should have to pay something like £2,000 an acre for any extension of our works, and then be exposed later on, if we wished to further increase them, to still larger demands, I strongly urged the Board to make the purchase of the whole estate at Haigh Park. This the Company did not see its way to do at the time, and Mr. William Elmore very pluckily stepped in and bought the property. Later on, when the land had increased in value, and we saw the bargain that Mr. Elmore had, we readily accepted his generous offer to let the Company take over the purchase at the original price. Since that time, as we have mentioned, the value of the land has greatly increased, and I will read you a letter from a gentleman who is acknowledged in Leeds to be the greatest authority on the value of land in that neighbourhood. He writes as follows:

"Aire and Calder Navigation, Leeds, December 26, 1891.

"My dear Atkinson,—You ask me my views in regard to the Haigh Park Estate, lately belonging to Lord Stourton, and now acquired by a company with which I believe you are connected. It is a valuable property, and in the near future must become exceedingly so, as any considerable extension in the manufacturing industries of Leeds must necessarily be in that direction, for there is no land so suitable or now available. I do not know whether you are aware of the fact that the proposed South Leeds Junction Railway of the coming session passes through the estate on its

western side. This, if passed by Parliament, will enhance the value of the estate, although it is already exceptionally situated by having the Aire and Calder Navigation, with its easy connection, on one side, and a junction with the Midland Railway on the south side.

"Altogether, I think the Company have done well to acquire the estate, and especially if they can afford to wait a while before realising.—Yours sincerely, W. H. BARTHOLOMEW."

In addition to this and the other advantages set out in the report, the Midland Railway Company have not only agreed to spend a considerable sum in improving the means of communication with the estate, but have also arranged, later on, to build a passenger station contiguous to our property. In justice to Mr. Elmore I must say that he has worked like a Trojan, and, even if he has been slow in getting our Company to its present prosperous position, he has nevertheless given one of the greatest possible proofs of his zeal for the Company, and his interest therein, by giving up his purchase precisely on the same terms as he had procured it. If he had been a stranger, there would have been nothing wrong in his asking £25,000 profit on the price, and then we should have had a bargain; in fact, if at the end of a year or two the Company do not find that they have made a splendid bargain, I shall be very glad to take it off their hands. I think, therefore, that our thanks are very much due to Mr. Elmore for the excellent position he has put us into in that respect, and I have no doubt that, before we part, you will favour him with a vote of thanks instead of a cheque for the profit he might otherwise have made. Three members of the Board retire. Sir John Morris is not allowed by his physician to offer himself for re-election, but possibly he may be able to join us again later on. With regard to the other two members, Mr. Carson and myself, I may say that Mr. Carson, from his knowledge as a director of the Cape Copper Company, of which he was originally the manager, has been of great assistance, and is one of the four largest holders of our shares. I myself have every confidence in the great value of this invention, and have had ever since it was only an idea in the mind of the inventor. I hold over 8,000 shares in the Company, and have upwards of £40,000 in the various Elmore companies, and have never sold a single share, even when they were at £8 each, which figure I believe they will soon be at again. On the contrary, I have been steadily increasing my holding. In fact, I may say the Directors of your Company are by far the largest holders in the Company, holding, I believe, nearly a third of the issued capital. The Chairman then read a report from Mr. Elmore, confirmatory of his statements, to the following effect:

"I beg to confirm my report of November 30 last, and the gratifying results I was then able to foreshadow, and to state that our experience since more than bears out my figures. Since my previous report of June 1, 1891, the new copper mandrel has proved to be all that I then claimed for it, and it even exceeds my expectations, simplifying the process immensely. I send you the two tubes recently tested by an independent expert, one made by our electro-burnishing process and the other one a brazed tube of the best ordinary make. The result of the trial you already know of—viz., that the Elmore tube turned out to be not only more than three times as strong as the best brazed tube, but of such high uniform quality that, although the testing machine had to be specially made, the machinery actually gave way two or three times in the course of the tests, and had to be strengthened to meet the great resisting power of the Elmore tube. From this it will be seen that the Company will practically have the monopoly of steam-pipes of large diameter, and that marine engineers will at once abandon the use of brazed copper pipes, which have given them so much trouble of late by bursting under the high steam pressures used in the triple and quadruple expansion engines, some 50 or 60 lives having been lost during the present year from this cause; and I may state that we have already received some important communications and assurances to this end. The difference in the two kinds of tubes cannot be better expressed than in the words of the eminent engineer who made the test, as follows: 'I beg to inform you that I have to-day witnessed the bursting of two experimental copper pipes, one made by your electro-burnishing process, the other an ordinary brazed tube, made by a first-class coppersmith in Leeds. The first pipe is 5ft. 6in. long, 9¼in. in diameter inside, and ¼in. thick. The pressure was applied to the inside of this pipe by means of a three-throw hydraulic pump driven from the shaft in the shop. Up to a pressure of 1,000lb. per square inch the pipe showed no signs of distress. At a pressure of 1,176lb. to the square inch the pipe commenced to expand in the middle uniformly, until this part of it became ⅜in. larger in diameter than the other part, and water commenced to pass from four separate points almost opposite to each other, showing that the metal was stretching uniformly, and that the pipe was almost on the point of bursting. The pressure was again increased until 1,456lb. to the square inch was reached, when the pipe stretched at this part from 9¾in. outside diameter to 11in., and at this pressure it burst, opening out in the centre of the pipe for a distance of about 10in., the fracture being 1¼in. wide. The pipe was afterwards measured, and it was found that although at the moment of fracture its diameter was 11in., and the metal had stretched uniformly to that extent, still when the pressure was released the pipe returned to a diameter of 10⅜in. The next pipe—that is, the brazed one—was 9in. diameter, also 5ft. 6in. in length and ¼in. thick. At a pressure of 120lb. to the square inch, one end of the pipe swelled to the extent of ⅛in. in diameter for a distance of about 12in. from the flange, and as the pressure was increased to 300lb. the opposite ends swelled in like manner, which clearly proves that in heating the copper to flange it at each end its ultimate strength had been greatly reduced. The pressure was again increased to 448lb. to the square inch, when the pipe burst at one end, about 12in from the flange, through the brazed joint, thus demonstrating that the electro-burnished pipe, although ¼in. larger in diameter than the brazed pipe, was 3¼ times stronger, and further demonstrates that owing to the great ductile properties possessed by the electro-burnished copper, which admits of its being flanged without being heated, enables pipes of this description to be constructed of a uniform strength throughout.' It is important to notice that the Elmore tube was flanged (in the ordinary way by an ordinary workman) without annealing, thus preserving to the metal its whole original strength, and avoiding all possible chance of deterioration of the metal by overheating owing to want of skill or carelessness on the part of the workmen. As showing the rapidity of the growth of our trade, and the favour in which our goods are held by those who have tried them, I would state that we have already, during the last two months, added no less than 130 customers to our list, comprising some of the best firms in the country. We have executed 342 orders, and have to-day more orders offered than we can possibly execute. Further, one large buyer has given 16 repeat orders; one has repeated orders 14 times; two have repeated orders 12 times each; three have repeated orders 11 times each; two have repeated orders nine times each; five have repeated orders seven times each; three have repeated orders five times each; seven have repeated orders four times each; 10 have repeated orders three times each, and an aggregate of 224 repeat orders have been received from a number of our customers, representing about 40 per cent. of the total names upon our books. We have on hand orders and offers of orders at prices above those that I estimated in my last report, which will far more than fill our capacity for a long time to come. In addition, since the 20-ton plant was started we have received specifications and sent out quotations in reply to enquiries for 1,561,669lb., or over 700 tons, of copper tubes for various purposes, besides a large amount of copper to be deposited upon rams and other expensive articles, from which to draw our orders and keep our tanks constantly employed. I further have pleasure to officially inform you that another stage in the realisation of the promises that I have made has been reached, which, with the exception of the delay in actual completion, have been more than borne out in every case. This important step is the satisfactory production of a copper cartridge case, the value of which may be gathered from the fact that it means the successful application of the Elmore process to pans for brewers and distillers, and other articles not of tubular form but having a bottom. From the samples I send it will be seen that not only is the copper cylinder closed at one end, but the thickness of the copper can be regulated at will, to be thick at one part and thin at another, as desired, whilst the quality is kept at the same high standard as our tubes. If it is possible, as has been proved, to produce such an article by the Elmore process, it can at once be seen by any expert that it is far easier to produce than an ordinary pan, and in my estimate of profits, which I made out on November 30 last, no allowance whatsoever was made for such special articles, the extra profit upon which will all be in addition to what was there set out; and the fact that I am at present negotiating for making arrangements for the granting of a license for the manufacture of a minimum of 10 tons of these cases per week, on a royalty that will be most remunerative to this Company, will show that I have erred on the safe side in making out my estimate of profit. In this report of to-day I have confined myself to what has actually been done and proved, and I consider it unnecessary to refer to the fact that our process is equally applicable to the deposition of other metals, and the manufacture of heavy ordnance, of a quality hitherto unknown, and I think you will find, as in the past, that every statement ever made by me as to the various applications of the process will be as fully borne out as those regarding the turn-out of copper tubes and such-like articles; this I have been able to prove to you to-day."

The **Chairman** then moved the adoption of the report and accounts.

General Fyfe seconded the resolution, which was agreed to.

Mr. Pilcher said he had given the Company an order for two steam-pipes for marine purposes to stand 165lb., but they were laminated throughout. He would like to know the reason of this; also how the cost would compare with that of the ordinary pipes for marine purposes.

Mr. Elmore said that at the commencement they unfortunately started with a defective engine, which, although constructed by one of the best engineering firms in the world, had broken down continually. The breaking down of the engine caused the operations to cease in the tanks, the process being essentially a continuous one. That was the cause of the lamination, and when he became the managing director at the works he found that some of the tubes had been sent out which were made during that early time, amounting to six in all. If Mr. Pilcher would favour the Company with another order he believed they would be able to satisfy him. An official test was about to be made in conformity with the Board of Trade specifications, which he believed would be in every way satisfactory.

Mr. Pilcher: Will you guarantee them, and put in the ordinary tubes if yours are a failure?

Mr. Elmore: Yes; with pleasure.

Mr. Pilcher: Then I will undertake to give you an order.

Mr. Rawson: I will send you a cheque for £500 if the tube proves in any way defective.

Messrs. Atkinson and Carson were re-elected directors, and Messrs. Price, Waterhouse, and Co. were re-appointed auditors.

Dr. Cantrell next moved a vote of thanks to Mr. Elmore and the Company's staff.

Mr. Guarricino seconded the resolution, which was agreed to.

The meeting closed with a vote of thanks to the Chairman and Directors.

NEW COMPANIES REGISTERED.

California Gas, Water, and Electric Lighting Company Syndicate, Limited.—This Company has been registered with a capital of £2,000, in £1 shares, to purchase or otherwise acquire, work, manage, and turn to account gas works, electric light plants and water works in the U.S.A., Canada, or the British Colonies. Registered office, 20, Bucklersbury, E.C.

Chloride Electrical Storage Syndicate, Limited.—Formed, with a capital of £262,500, to acquire certain patents and property, to carry on business as ironmasters, copper smelters, steelmakers, ironfounders, engineers, boilermakers, metallurgists, electricians, electrical contractors, electrical and mechanical engineers, and suppliers of electricity, and to carry on the business of an electric lighting company. The subscribers are: Messrs. J. E. Yeates, 9, Solent-crescent, West Hampstead; W. J. Torney, 24, Granard-road, Wandsworth Common; S. S. P. Cooke, 53, Chadwick-road, Peckham; R. J. Rumball, 46, Ruvigny-gardens, Putney; F. B. Liley, 58, Sandmere-road, Clapham; S. S. Ludlow, 34, Werter-road, Putney; and E. J. Newball, 57, Cowley-road, North Brixton.

Liverpool Metal and Hardware Company, Limited.—Registered by J. and R. Gole, 4, Lime-street, E.C., with a capital of £12,000 in £10 shares. Object: to acquire the undertaking of P. C. McIntyre and Co., Limited (of Hanover-street, Liverpool), in accordance with an agreement made between J. Huntington of the one part and this Company of the other part, and generally to carry on business as general metal and hardware merchants, mechanical and electrical engineers, etc., in all their respective branches. There shall not be less than three nor more than eight Directors. The first are J. Baker, J. Huntington, C. Coward, W. Heaton, J. G. Russell, P. B. Coward, and J. W. Baker. Qualification, £500. Remuneration, £150, divisible.

PROVISIONAL PATENTS, 1891.

DECEMBER 14.

21816. **Improvements in incandescent lamps.** Carl Schubel, 45, Lawford-road, Kentish Town, London.

21833. **Improved method of reducing the thermic loss by radiation from the sides of thermo-dynamic motors.** Benjamin Howarth Thwaite, 37, Victoria-street, Liverpool.

21849. **Improvements in armatures for dynamo-electric machines.** Buchanan Stewart Paterson and John Brokenshire Furneaux, 46, Lincoln's-inn-fields, London.

21854. **Improvements in or relating to the insulation of electrical conductors.** Alfred Julius Boult, 323, High Holborn, London. (Emile Louis Montgolfier and Charles Valéry Montgolfier, France.)

DECEMBER 15.

21870. **Improvements in voltaic cells or batteries.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward A. Clark, United States.) (Complete specification.)

21923. **An improved electrical apparatus for driving clockwork.** Frederick Herbert Berry, 186, Fleet-street, London.

21941. **Improvements in electric motor mechanism for vehicles.** William Gumbley, 53, Chancery-lane, London.

21961. **Improvements in variable resistance devices for relays, telephones, and the like.** Henry Harris Lake, 45, Southampton-buildings, London. (Charles Cuttriss, United States.) (Complete specification.)

21963. **Improvements in converter systems for electric railways.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

DECEMBER 16.

21987. **Improvements in suspending telegraph and telephone wires and attachments on open-air supports of same and telephonic switchboards.** George Rodenhurst Stokes, 67, Piccadilly, Hanley, Stafford.

22025. **Improvements in fittings for electric lights.** John Smallwood, 33, Southampton-buildings, London.

22027. **Improvements in gallery holders or supports for the globes or shades for electric lights and gas lamps, also applicable to holders for incandescent lamps.** Victor Silberberg, 226, High Holborn, London.

22030. **Improvements in the electrolytic treatment of copper and silver ores.** Carl Hoepfner, 45, Southampton-buildings, London.

22037. **Improvements in printing telegraph receiving instruments.** Henry Harris Lake, 45, Southampton-buildings, London. (John Edward Wright, United States). (Complete specification.)

DECEMBER 17.

22126. **An improvement in secondary batteries.** Alfred Ernest Porter, 48, Richmond-road, Paddington, London.

22109. **Improvements in systems of electrical distribution especially adapted for supplying electric motors.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Harry Ward Leonard, United States.)

22120. **Improvements in telegraph repeaters.** Albert Carlos Booth and William Percy Ward, 106, Victoria-chambers, Chancery-lane, London.

22122. **An improved electric switch.** Maurice Hoopes, 106, Victoria-chambers, Chancery-lane, London.

DECEMBER 18.

22145. **Improved jar or cell for galvanic batteries.** William Phillips Thompson, 6, Lord-street, Liverpool. (Otto Hirsch, Germany.)

22178. **Improvements in electric accumulators or secondary batteries.** Frederic Morin, 45, Southampton-buildings, London.

22181. **Improvements in packets or pads for electric cells.** Lewis Hopkins Rogers, 18, Buckingham-street, Strand, London. (Complete specification.)

22184. **Improvements in or relating to telephones and microphones.** Adolf Rettig, 18, Buckingham-street, Strand, London.

DECEMBER 19.

22255. **Improvements in electric telephone transmitters.** Alan Archibald Campbell Swinton, 66, Victoria-street, Westminster, London.

22265. **Improvements relating to simultaneous telephony and telegraphy.** Johnston Stephen and Charles Davis, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED

1890.

19740. **Column printing telegraph receivers.** Higgins. 11d.

1891.

184. **Dynamo machines.** Crompton. 8d.
185. **Dynamo machines.** Crompton. 8d.
284. **Telephone transmitter.** Mayer. 6d.
899. **Electric cells.** Eagar and Milburn. 4d.
1176. **Dynamo-electric machines, etc.** Newton and Hawkins. 8d.
1318. **Electric distribution.** Cutler. 11d.
3664. **Electrical switches.** Binswanger. 8d.
17399. **Dynamo-electric machines.** Gilliland. 8d.
17733. **Electric drilling, etc., machines.** Linders. 6d.
18522. **Welding metals electrically.** Thompson (Coffin). 6d.

BUSINESS NOTES.

Fog Signals.—We understand that a syndicate is being formed for £25,000 to purchase half of the patents of the fog-signal system we described last year, and negotiations are proceeding.

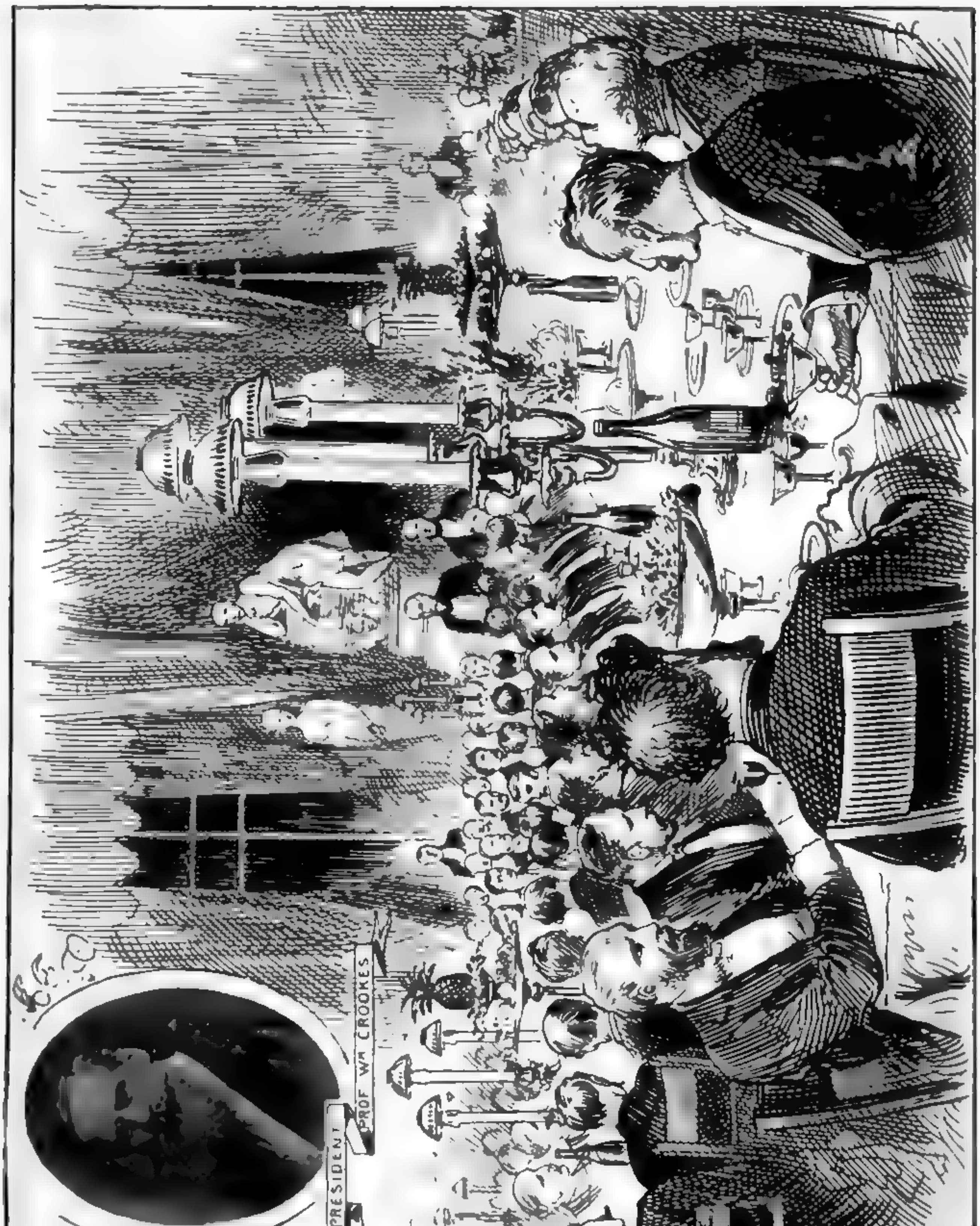
Commercial Cable Company.—The numbers are published of 1,200 mortgage debentures of £100 each of the Commercial Cable Company, which have been drawn for payment at par on January 15 next.

City and South London Railway.—The receipts for the week ending December 27, 1891, were £871, as against £785 for the corresponding week in 1890, showing an increase of £86. The aggregate receipts for half-year to date were £19,221.

"**Electrical Plant.**"—Mr. E. R. Dolby retires from the editorship of the monthly journal *Electrical Plant*, after editing the special "central station" number and the ordinary January issue, 1892, and will devote his entire attention to his consulting practice at 8, Princes-street, Westminster. The proprietors of *Electrical Plant* have turned the business into a limited company, and owing to increase in size, the work will now require the whole time and attention of an editor. Mr. H. Cuthbert Hall, who has acted as assistant for the special number, will undertake the work, the offices of the journal being at 52, Queen Victoria-street, E.C.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{3}{8}$
— Pref.	—	$2\frac{1}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	$19\frac{1}{2}$
House-to-House	5	5
Metropolitan Electric Supply	—	$10\frac{1}{8}$
London Electric Supply	5	$1\frac{3}{8}$
Swan United	$3\frac{1}{2}$	$4\frac{1}{2}$
St. James'	—	9
National Telephone	5	$4\frac{3}{8}$
Electric Construction	10	7
Westminster Electric	—	$6\frac{3}{8}$
Liverpool Electric Supply	5	$5\frac{1}{8}$
	3	$2\frac{1}{4}$



PROF. W. CROOKES, PRESIDENT, SPEAKING AT THE INSTITUTION DINNER.

ONE OF THE FOUNDERS.

GENERAL WEBBER, C.B.

PAST-PRESIDENT.

Mr. W. H. PREECE, F.R.S.

PRESIDENT, 1892.

PROF. W. E. AYRTON, F.R.S.

THE SECRETARY.

F. H. WEBB.

VICE-PRESIDENT.

SIR DAVID SALOMONS.

NOTES.

Islington.—We understand that Colonel Gouraud is organising a company, with a large capital, for furnishing the electric light to the Islington district.

South American Cables.—The Western and Brazilian Telegraph Company, Limited, notify that direct communication by their cables with Monte Video and Buenos Ayres is now restored.

Patent Office Library.—It is hoped that a technical library will be established on the ground floor of the new Patent Office extensions. The alteration, if carried out, will be greatly appreciated.

Electric Fireworks at Chicago.—The Committee on Ceremonies has appropriated 25,000dols. for electric fireworks at the time of the dedication of the exposition buildings in October, 1892.

Mining Plant.—At the meeting of the Chesterfield and Midland Counties' Institution of Engineers on Saturday, Mr. M. Deacon will read a paper entitled "Notes on a Small Electric Pumping Plant."

Fatal Accident in Italy.—A fatal electric lighting accident occurred on Saturday night at the Theatre Mangano at Palermo. One of the men inadvertently took hold of both connecting wires, and fell dead.

Correction of Address. — Messrs. Vaughan and Brown inform us that their address is 16, Kirby-street, E.C., and not Purdey-street, Hatton-garden, as given in the list of exhibitors at the Crystal Palace.

Presidential Address.—The first meeting of the Institution of Electrical Engineers for the coming year will be held on the 14th inst., when the president, Prof. W. E. Ayrton, will deliver his inaugural address.

Shrewsbury.—Mr. Richard Hanway has written a letter to the *Shrewsbury Chronicle* giving a considerable amount of useful information to intending users of this illuminant, in a clear and straightforward style. The interest in the neighbourhood on this subject seems to be keen.

Morse Wires.—One of the exhibits that the Baltimore and Ohio road expects to show in the Electricity Building is a model of the first telegraph wire strung along that line by Morse. The line was nine miles long and extended from Baltimore to Relay Station. The line was laid in a lead pipe.

Salford.—At the Salford Town Council on Wednesday, in answer to a question by Alderman Dickins, the deputy-chairman of the Gas Committee (Mr. Philips) said that a sub-committee had been appointed to consider the subject of electric lighting in the borough, and their report would be submitted in due time to the Council.

French Journal.—*L'Industrie Electrique*, the new French technical journal, is to be issued with the beginning of the year. The editor, as we have already stated, is M. E. Hospitalier, who we were glad to welcome recently on a visit to England with reference to the recent progress in electric underground railways and other matters.

Appointment.—Mr. Alfred Hay has been appointed demonstrator of electrical engineering at the University College, Nottingham. Mr. Hay served his apprenticeship at the Faraday Electrical Works, Govan, and studied electrical engineering at the Glasgow Technical College, under Prof. Jamieson, thereafter taking the Edinburgh University B.Sc. degree.

Electric Heating.—The Maloja Kursaal on the Engadine is to be heated electrically during the winter by power derived from the Mera river in Aseima. There is no doubt that considerable use will be made of electric heaters in those cases where natural power is abundant, and it is probable that this department of electrical engineering will become exceedingly important in such cases.

Overhead Trolleys. — The Common Council of Brooklyn, U.S., has given permission to the tramway companies to change their motive power to the electric overhead trolley system. This decision, which is expected to be at once confirmed by the State Railroad Commissioners, will mean the expenditure of £2,400,000 during the next two years on the Brooklyn tramways.

Electric Fire Alarm.—A development of the electric fire-alarm system has been put into practice at Boston, U.S.A., by the application of the call system to a cab-driver's stand. On an alarm being given, the cabman wakes, the horse is harnessed, and word is given of the address of the owner of the threatened premises, who when fetched is usually able to afford helpful information.

Chicago Exhibition.—From an advertisement in another column it will be seen that applications for space in the British section may now be addressed to the secretary of the Royal Commission for the Chicago Exhibition, at the offices of the Society of Arts, John-street, Adelphi, W.C., where prospectuses and forms of application can be obtained. The date previous to which applications must be received is February 29 next.

St. Elmo's Fire.—A correspondent of the *Glasgow Herald* state that on the 28th ult., when he and another gentleman were walking in a driving shower of hail, the tips of their umbrellas had a glow of fire similar to that from a frictional machine. Was it, he enquires, due to the state of the atmosphere, the charge given by the hailstones, or the friction of these latter on the silk? It is, at least, an interesting occurrence to record.

Electric Conduits.—The Johnstone patents for the protection and preservation of electric wires underground, says the *Financial News*, have been acquired by an English syndicate, and will be brought before the public shortly. Mr. Johnstone hails from Philadelphia, and at a Clover Club dinner was once christened "Lightning," in contradistinction to Mr. Johnstone, the lawyer, whose deep bass voice acquired for him the sobriquet of "Thunder."

Electricity and Life.—Prof. M'Kendrick, F.R.S., of the University of Glasgow, has been giving an exceedingly interesting set of Christmas lectures at the Royal Institution upon "Life and Motion," dealing principally upon the part played by electricity upon muscular activity. Prof. M'Kendrick's lectures cannot fail to bring home to many minds interested in physiology and biology the great share that electrical action has in the still unsettled problems of life, muscle, and nervous energy.

Works on the Telephone.—Messrs. Whittaker and Co. have made arrangements with the editor of *El Telegrafista Espanol* for the translation into Spanish of Mr. Preece's work upon "The Telephone." The book already has been translated into both French and German. The same firm will publish shortly, in a cheap form, Mr. A. R. Bennett's papers on the "Telephoning of Great Cities" and the "Electrical Parcel Exchange System," which attracted considerable attention at last year's British Association meeting.

Marine Lake at Southend.—In order that visitors to Southend may be able to indulge in boating and other amusements on the water at all hours of the day without having to go a distance of a mile or more along the pier, a company is asking for incorporation with the object of constructing, in conjunction with the Local Board, a

marine lake, forty acres in extent, on which miniature steamboats, yachts, and pleasure boats would be let on hire. Here is a chance for the General Electric Traction Company and their launches.

Preston.—The staff of the National Electric Supply Company, Limited, Preston, and a few friends, held their first annual supper on New Year's eve, to celebrate one year's work of the electric lighting of Preston. The chair was taken by F. F. Bennett, Esq., M.I.E.E., supported by the committee—viz., S. F. Emerson, T. Cross, S. Powell, and C. Gillin. Toasts were proposed to the "Queen," the "Directors," the "Managers," and the "Guests"; after which music and singing were indulged in to an early hour, and altogether a very enjoyable time was spent.

Electric Ploughing.—Mr. A. A. Denton, of the United States Department of Agriculture, is seriously advocating the use of electric motors instead of horses in the great plains of the West for ploughing, sowing, reaping, harrowing, and thrashing. The problem involves the backward and forward movement of a machine in a straight line of half a mile, passing to and fro until the field is covered. "We shall wonder," says Mr. Denton, "a few years hence how man produced food by means of the whip. There is [illegible]nt demand in agriculture for electrical engineering."

Shiplighting at Devonport.—Arrangements have just been completed at Devonport for lighting the ships under construction by electricity. The system has been in use for some years at Portsmouth, but has never previously been introduced at Devonport, whilst at Chatham it was tried and abandoned, owing, it is stated, to the expense. On board the "Edgar," at Devonport, a portable dynamo, engine, and boiler has been placed, which is capable of lighting 360 lamps. The cost of such lighting is estimated at £2 a day. Three vessels on the building slips have also been similarly illuminated, with good results.

An Electric Lamp Thief.—A thief who has for a long time, in all probability, been stealing incandescent electric lamps at the Paris theatres, has just been arrested by a clever device of the management of the Porte St. Martin. As it was found that a great many lamps had disappeared at the house the electrical engineer so arranged the fittings that immediately a lamp was removed the electric current sounded an alarm. The man was thus caught as he was making away with a lamp in his pocket, and, as he refuses his name and address to the police, it is believed that he has a large store somewhere of the stolen articles.

St. Pancras Lighting.—The St. Pancras Vestry have deposited a Bill, which will be introduced into Parliament next session, under which powers are sought to raise £60,000 for the electric lighting of the whole of the parish, in addition to any sum that may be required for paying the costs of obtaining this Act. The period for the redemption of the loan is fixed at 42 years. The Vestry also seek power by this Bill to appropriate for electric lighting purposes the pneumatic tubes laid by the Pneumatic Despatch Company, but now abandoned, in Tottenham Court-road, Euston-road, Hampstead-road, and Drummond-street.

Limerick.—Indications seem to show that electric lighting is progressing in Ireland, if not more rapidly than in England, yet with rapid strides. Amongst others, the city of Limerick has now decided to apply at once for a provisional order, the special meeting of the Corporation adopting a resolution to that effect proposed by Mr. Bernal. Mr. Conolly, the law adviser to the Corporation, stated that the cost would be about £200. Mr. Clune said that the cost of gas was greater in Limerick than in any other town of its size, whereat Mr. Conolly stated that when the debt of £4,000 odd was paid, which was being done, the price would be put down.

Pontypool.—A company having for its object the lighting of the town of Pontypool by electricity is being formed, and an influential meeting of tradesmen and others interested will be held at once. As the Local Board cannot obtain the necessary powers for nearly two years, the company will at first be a private one, to be eventually transferred to the Board at the original cost, and the profits made will then be spent on improvements in the town. The directors, it is stated by the *South Wales Daily News*, are in a position to guarantee a dividend of not less than 10 per cent., the project having been most warmly received, and the promises of support already given more than sufficient to ensure this desirable result.

Overhead Wires at Chelmsford.—The Fire Brigade Committee reported to the Chelmsford Town Council at their last meeting with reference to the communication from Messrs. Crompton and Co. as to the cutting of the electric light wires in case of an outbreak of fire in proximity thereto. A representative of Messrs. Crompton and Co., who attended the meeting of the committee, stated that the lighting of the town was divided into four sections, and that in case of fire the light could, if necessary, be cut off in one section only. The committee recommended that Messrs. Crompton and Co. be asked to take such steps as they thought necessary to prevent any danger from the wires in case of fire. The report was adopted.

Teignmouth.—The Teignmouth Local Board finding that the increasing demand for gas is likely to necessitate extensive alterations at their works, are considering the desirability of introducing electric light, and have asked Mr. H. D. Massingham, the well-known electrical engineer, who has had considerable experience of public lighting by electricity, for an estimate of the cost of an installation. The matter was considered at a special meeting on Saturday, Rev. Anson Cartwright presiding, when the Board had a consultation with Mr. Massingham. The estimate was discussed at length, but no definite details of the scheme can yet be given. It is thought fairly certain, however, that electric lighting will be adopted.

Paris Exhibition.—A detailed analysis of the accounts of the great Paris Exhibition has been published, from which it appears there is a balance of £400,000 to the good; £90,000 was received for concessions for cafés and restaurants, and £2,000,000 were received for admissions, or £280,000 more than expected. On the other hand, the expenditure, which had been estimated at £1,860,000, was only £1,600,000. In other words, while the 1889 exhibition left a profit of £400,000, that of 1867 gave one of only £112,000, and that of 1878, organised at the cost of the State, left a deficit of £1,268,000. It should be pointed out, however, that in 1878 there was no subsidy from the State, whereas in 1889 the State contributed £680,000, and in 1867 £240,000.

Portrait of Benjamin Franklin.—Mr. David Murray, 169, West George-street, Glasgow, writing to the *Glasgow Herald*, asks if anyone can tell him of the whereabouts of a repli[illegible] of the celebrated portrait of Benjamin Franklin, painted by the French artist Chamberlin, which is said to be in Scotland. The Hon. Robert C. Winthrop, of Boston, late pr[illegible]ent of the Massachusetts Historical Society, says (Massachusetts Historical Society *Proceedings*, xv., pp. 160-161) that it is in the possession of a member of the William Penn family in Scotland. Who this is, or where the portrait is, he has not been able to ascertain. The information is sought for the memorial volume on the

centennial of George Washington's inauguration, now being completed in New York.

Kendal.—The Town Council of Kendal are exercised upon the question of overhead wires. Councillor Hargreaves, at the last meeting, said he understood that certain parties were supplying customers with electric light, and he wanted to know the rights of the case. The town clerk said that if anyone wished to establish themselves under the Electric Lighting Acts they would have to get the permission of the Board. Later, the application of Mr. Gilkes for permission to erect poles leading from the Canal Iron Works to his house came before the Council. It was mentioned that permission had been asked only after the posts were erected, and to this objection was taken. Councillor Jeffreys stated that there was not the least danger from Mr. Gilkes's wire, and the matter was passed.

Manchester.—It will be remembered that the proposal of the engineers at Manchester, with reference to electric lighting, was that the electric plant should be established on the same site and in the same engine-house as the hydraulic power plant. The Gas Committee, at their last meeting, arrived at a decision electrical engineers will approve, that having regard to future developments and the probabilities of extension of both electric light and hydraulic power, the site at Dickinson-street be allotted entirely to the electric central station, and that in Gloucester-street to hydraulic power. The tenders for boilers and engines have already been advertised for, and with this practical and sensible attitude, we doubt not that Manchester will achieve a successful result from both public and electrical points of view.

Liverpool Overhead Railway. — Among the Bills which have been deposited in Parliament for the coming session is one which proposes to carry out a line of overhead railway similar to that adopted in New York. In previous years Parliament has authorised such a line in connection with the Mersey Dock at Liverpool, which is now in course of construction by the Liverpool Overhead Railway Company, and application is now to be made to extend the time for the execution of the works already authorised, and, in addition, to extend the line both northwards and southwards. The company is to be empowered to work the railways either by electricity or steam, and there is also a provision authorising the Corporation of Liverpool to contribute to the capital of the company for the purpose of carrying out the scheme.

Bombay Docks.—The electric light has now been installed at the Prince's and Victoria Docks, Bombay. Three lights are run up at an average height of about 70ft.; one light for each dock, and a central one between both, erected on a gigantic overtopping mast. It is constructed of iron as far as the crosstree and of timber upwards. The engine-house is not yet finished, but the erection of the lights was considered of so much importance that the light was started before the completion of the premises. The success of the installation is due in a large measure to the indefatigable exertions of Mr. A. M. Taylor, engineer to Messrs. Siemens Brothers, of London, who have supplied the plant. Preliminary experiments had been conducted to the satisfaction of the Dock Committee under the immediate supervision of Mr. Taylor before the final installation was commenced.

Finsbury Special Lectures.—On January 20, 1892, Mr. A. Reckenzaun begins a course of six lectures on "Electric Locomotion," dealing with electric tramways and railways. These will be given on Wednesdays at half-past seven. Through the spring, also on Wednesdays, Mr. Rousseau's practical classes will be held in the new electroplating laboratory, in connection with which Prof. Thompson will give three special lectures on dates to be announced. On February 9 and succeeding Tuesdays, Mr. W. C. Clinton will give a short course on vector methods of calculation in relation to electrical problems, being an introduction to the writings of Mr. Oliver Heaviside; Prof. Perry is continuing his course on the application of the differential and integral calculus, and will conclude by an exposition of Fourier's theorem in relation to alternate currents and the use of the electro-dynamometer in harmonic analysis. Prof. Silvanus Thompson continues his ordinary course of Monday lectures, the topics until Easter being transformers, alternate-current motors and the design of continuous-current dynamos.

City Lighting.—The abominable Christmas weather has led business men in the City to see the advantages likely to accrue to users of the electric light. "It can but be admitted," says the *City Press*, "that while the lighting of the streets is vastly improved, the illumination of private establishments, such as shops, offices, and warehouses, by the electric light will contribute vastly to a general improvement. The wholesale miseries from which the citizens suffered during Christmas week—to say nothing of the damage to property, and increased expense, by reason of the filthy and suffocating fog which enshrouded everything—must have convinced all that the present means of combating the fog-fiend are utterly inadequate, while at the same time the use of gas does not tend to improve matters. It is probable that the contracts held by the City of London Electric Lighting Company may not be actually completed by February, although an honest attempt is being made to do so; but in the event of the work being unfinished a small extension of time would facilitate matters." We are glad to see such a helpful attitude.

Telephonic Facilities. — The National Telephone Company will introduce a Bill into Parliament next session by which they seek to obtain additional facilities for conducting the business of telephonic communication. The Bill, subject to certain provisions as to the consent of road authorities and the repair and reinstatement of roads, gives the company power to place and maintain telephone wires under any public road and to alter or remove the same; to place and maintain a telephone wire over any public road or over any land or any estuary or branch of the sea, and to attach a telephone wire to any land, and to maintain posts on any land, and alter or remove the same, giving compensation to all bodies and persons who sustain damage by reason of their action. In the case of attaching wires to private property, it is provided that where the owner and occupier are not the same person, the consent of the occupier shall be sufficient during the term of his occupation, but no longer. The New Telephone Company, Limited, have also introduced a Bill for the purpose of reincorporating the company and defining its capital, objects, and powers.

Death.—Mr. Frederick R. Leyland, president of the National Telephone Company, died suddenly on Monday night in a train on the underground railway between the Mansion House and Blackfriars Stations. Soon after leaving the former station he was seized with a fainting fit, and Colonel R. Jackson, who was riding with him, called the guard's attention to him at Blackfriars Station. He was at once carried into the waiting-room. Dr. Green was quickly on the scene, but upon examination Mr. Leyland was found to be dead. Mr. Leyland was formerly connected with the steamshipping house of Messrs. Bibby, Son, and Co. Mr. Leyland, in 1873, established the line of steamships connected with his name, which now comprises 23 vessels. He lived for the greater part of the time at his London residence, 49, Prince's-gate, his Liverpool

residence being Woolton Hall. He was an accomplished linguist, a connoisseur in fine arts, and possessed a collection of fine paintings. He was an expert in shipping matters, and besides holding the position of president of the National Telephone Company, was one of the directors of the Edison-Swan Company. His death was very sudden, heart disease being thought the cause of death. His London residence was a most handsome mansion, his dream being to live the life of an old Venetian merchant in London. The walls are adorned with paintings by Millais, Rossetti, Burne-Jones, Watts, and others of the best English artists, besides examples of Bellini, Botticelli, and Raphael. He was 61 years of age and leaves a son and two daughters, one of the latter being married to Mr. Val Prinsep, R.A.

Gas v. Electricity.—There is an interesting interview in the *Daily News* of Monday with Mr. Orwell Phillips, of the gas works at Horseferry-road. Mr. Phillips metaphorically snaps his fingers at electricity, but trembles at the fourpenny petroleum lamp. With regard to electricity he says, what is to a large extent true, that the West-end mansions are not filched from the gas companies, but from the sellers of wax candles. The occupiers of the best houses will not use gas—it is too disagreeable, hot, dusty, evil-smelling a light to suit them. Candles were their resource until electricity came upon the field. An interesting fact, however, comes out with regard to the consumption of gas in Bond-street. Everyone who has visited this street knows that from end to end at least half the shops now use electric light. "Only as an advertisement," says Mr. Phillips—"look at the back shops and you will still find gas." And he has had the curiosity to compare the returns of gas consumption before Sir Coutts Lindsay put up his machines, and with the receipts four years later. He found that at the earlier period the receipts from Bond-street were £7,200, and at the later period £7,800. Perhaps, however, there lurks a mystery in the words "four years." If he examines five or six years later—what then ? Does this represent the year that is past or not ? But, at any rate, the increase, in spite of the substitution of some electric light, is interesting, and bears out what has been noticed in other parts. Will it continue—we shall see ; but it is necessary for gas managers to put a good face on it, and will be still more necessary for them to set about introducing large gas engines for producing electric light. This will be of use, and electrical engineers will then work with them.

Cost of Electric Energy.—The discussion in the *Financial News* upon the "sheer" cost of the production of electrical energy still continues, and promises to lead to interesting and important results. We shall have more to say upon the subject when the correspondence is complete ; meanwhile we will content ourselves in advising practical men to read the correspondence, and, if possible, give their experience in advocating the usefulness of electrical distribution to financial men. Mr. E. F. B. Harston apologises to Mr. Crompton for mixing him up with another company, but at the same time maintains that with any company charging 8d. a unit the bills will be three times that of gas. Mr. John W. Stringfellow, mechanical engineer and specialist, makes an offer to act alone, or in conjunction with others, as stakeholder of, say, £500 for a practical test of gas against electricity of 10 low-power and 10 high-power lamps, the installation to embrace complete plant in itself, and the fixed cost of working to be taken. He suggested the Thames Embankment as the best site for the proposed test. Mr. Albert Gay, manager of the House-to-House Company, objects to the statement that Crompton is a rival of their company, the districts being separate. He asks what is meant by sheer cost, and gives six heads : raw material, wear and tear, wages of men, salaries of officers, rent, etc., and general expenses, of which only the first and third he supposes to be included in "sheer cost." Mr. Harston returns to the charge, and asks, "Cannot the cost be reduced ?" and wished to know whether the companies cannot charge 4d. instead of 8d. a unit. Messrs. Crompton, answering Mr. Gay, admits the first three of the divisions of expenditure as included in "sheer" cost. They reiterate that they are prepared to prove to a committee that if gas and electricity were produced on a sufficient scale—say enough to supply two square miles of London—the cost of electricity would be as low, if not lower, than that of gas.

J. H. Holmes and Co.—Though late in the day, we venture to record the fourth annual dinner of the employés of Messrs. J. H. Holmes and Co., held on Saturday, the 26th ult, at The Crown Hotel, Newcastle-on-Tyne. About 50 persons sat down to dinner. After dinner a most enjoyable programme of music, vocal and instrumental, was listened to, and, in response to the toast, Mr. J. H. Holmes gave a very interesting account of the evolution of the firm of J. H. Holmes and Co. The firm was established in 1883, and made their first dynamo in June, 1885. This, they have recently heard, is still working very well. The first ship lighted on the Tyne was lighted by this firm, as was also the first ship hailing from the Tyne—viz., the "Tynesider." The fame of the Castle dynamo really commenced at the Newcastle Exhibition in 1887, and the same year the firm entered their present premises, which were doubled in less than two years. At the present time over 500 dynamos bearing this name are at work, and the six hundred and twenty-fourth machine is now being built. Mr. Holmes commented upon the good feeling which existed between the firm and its employés, and expressed the wish that this might long continue. Mr. Holmes was frequently applauded during the course of his remarks, and at the conclusion the whole company joined in the customary goodfellowship chorus. The toast to the firm's "Electrical Engineers" was responded to by Mr. Broadbent (the outside manager), who gave a brief summary of the year's work. He remarked that during the year the firm had completed over 90 installations, including ships, collieries, hotels, houses, etc., and had fixed over 11,500 lamps. The total number of dynamos erected on these installations was 95, having an output of 13,605 lamps of 60 watts each, or 816,300 watts. The number of dynamos made up to date during the year was 125, having an output of 2,650,000 watts. The meeting broke up after a very enjoyable evening had been spent.

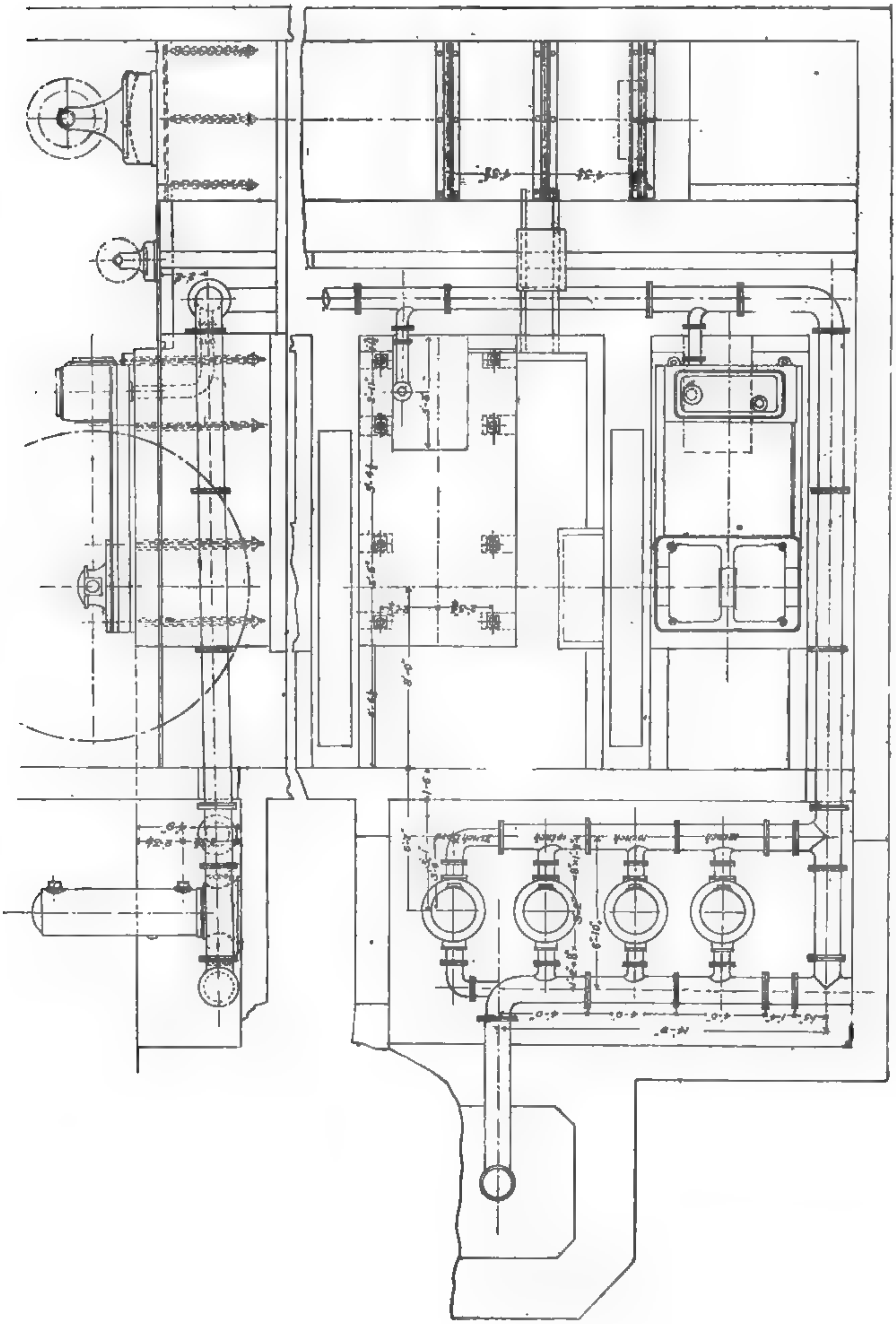
Electric Communication on Trains.—We have often wondered why more British trains are not furnished with electric safety communication with the guard and driver, instead of the ancient and often useless outside cord, for electric signals are common enough on the continental trains. We notice that a trial was made last week on the "Dandie" train running between Glasgow and Helensburgh, of a new system of electric communication introduced by Messrs. Shiels and Elliott, of Glasgow, which promises well. In the continental signals the handle is kept in place by a cord with lead plug attached, which can be broken by a forcible movement, which seems to us probably rather preferable to the necessity of breaking a glass and pushing a button. The latter is the method adopted on the Shiels-Elliott system, which embodies besides signal bells on engine and guard's van, and a red semaphore which protrudes from above the carriage when the signal is rung. This, of course, renders possible the

arrival of aid in the shortest time. The bells are connected by two trunk wires, which are carried throughout the length of the train, while two branch wires—one from each trunk wire—are led into each compartment, and terminate in an electric push placed under the parcel rack, and protected by a metal cap with a small circular pane of glass in the front of it, which the passenger breaks in order to press the alarm push, the glass being specially prepared so as not to injure the hand of the person breaking it. The connections are made by having at each end of the vehicle a tubular bracket carrying a flexible hose-pipe with a half-coupling at its end. These half-couplings are so arranged that when the carriages are brought together they can be interlocked by a simple movement similar in action to the coupling of the Westinghouse air-brake. The contact-pieces of the coupling are made on the double-wedge principle, pressing firmly on each other when the coupling is locked, and ensuring a good electrical connection. The coupling is also so constructed that should it have been omitted to unloosen it during shunting operations, it unlocks itself automatically, thus avoiding any damage being done to the electric system. The trial was considered entirely successful.

Newbury.—A correspondent, writing to the *Newbury Weekly News*, goes with some detail into the cost of proposed electric lighting in that town. After dealing with the question of using Dowson gas (a question we should like to see further discussed) he goes on to give "figures forwarded by one of the largest electric lighting companies in London, who are prepared to deliver and erect the various machines required at the undermentioned prices—viz., dynamo £500, storage batteries £500, transformer £550—the machines to be equal to the supply of an installation of 2,000 lights; and, further, these prices are subject to a discount of 30 per cent. for cash, so that the total cost of the machines will be about £1,000 net. The cost of the mains for the area designated in the order applied for by the Corporation will not amount to £2,000, including casing, breaking up the streets, and making good, and that sum will be considerably reduced if the mains are laid in the trenches opened for the sewers, so that the total cost of the requisite machinery and mains will not amount to more than £3,000, leaving £2,500 for alterations to mill, compensation for tenants' rights and contingencies; probably about double the amount that will be required. With regard to repairs and renewals," he continues, "provided the dynamos are of good manufacture and properly fixed, almost any electric lighting company will contract to keep them in repair for 5 per cent. per annum, and would make a good profit by so doing, as many of the recent pattern dynamos are not costing 2 per cent. for repairs. The accumulators will probably not require to be used more than 20 days throughout the year, and 1½ to 2 per cent. will amply cover their repairs and renewals. The transformer will not cost more than 1 per cent. to keep in repair; one that has been working at a very large installation in London has only cost 17s. for repairs during the 2½ years that it has been running. I purposely left out of my account the cost of repairs to mains as I knew that such enormous strides had been made in the improvement of the casing and other important details, that the figures of repairs of even two years ago would be fallacious, and I am now informed that many of the large companies will lay the mains and then keep them in repair at from 1½ to 2 per cent. per annum; so now we can total up the cost of repairs and renewals. Dynamos 5 per cent. on, say, £350, £17. 10s.; accumulators, say 2 per cent. on £350, £7; transformers, say 2 per cent. on £400, £8; mains, say 2½ per cent. on £2,000, £50; total, £82. 10s." As to estimate of receipts, he adds, 10s. per lamp supplied is an exceedingly low revenue, probably lower than any known. Mr. Preece's well-known estimate was based upon every lamp connected with the mains, and some had only been so connected a very short time.

Coast Communication.—Letters have again appeared in the *Times* upon that all-important subject to Great Britain as a kingdom—as a naval and commercial power—the safe coast communication by telegraph or telephone. Mr. A. Pendarves Vivian, in a letter dated January 1, 1892, points out that as to difficulty of connection to isolated lighthouses, we know that in the case of submarine cables, the cable has even now often to be protected by a channel cut in the rocks, cemented over afterwards. It would be possible also, he suggests, to protect it by cast-iron pipes. (We have before us at this moment a new flexible steel casing for cables, which it is possible might be used.) The difficulties, as Mr. Vivian states, are not new, for they have to be contended with, more or less, in submarine cables leaving a rocky coast, as at the South of Cornwall—near Penzance. "With regard to lightships," he rightly says, "there is more novelty in the difficulties to be overcome, but not for one moment would I believe that the same skill and ingenuity which are now so continuously shown by our electrical engineers would not speedily surmount them. I feel confident that any injury to the cable, such as would occur by the constant motion and the swinging of the ship, would be provided against, and that, if necessary, a movable joint would be forthcoming which would secure a perfect metallic contract, which we all know is a necessity. The whole matter resolves itself into a question of expenditure, and that it will be costly no one can doubt; but so are lifeboats, lighthouses, and lightships, all of which have the same object in view—namely, the protection and safety of valuable lives and cargoes." Mr. Robert Bayly, of Plymouth, writing on the same date points out that communication of the "Sunk" Lightship by telegraph and telephone to Walton-on-Naze when he visited it in 1889 was perfect, the telephone especially being preferred even in the worst weather. The experiments there extended over five years, and were apparently perfectly successful. Really, this question of coast communication is becoming intolerable. Mr. Preece has pointed out—and we have emphasised the fact—that the matter does not lie within the business of the General Post Office, which is a commercial agency for carrying messages and letters, and not for the saving of ships. This latter is a national affair, and all that is required is to introduce a short Bill next session for an appropriation of, say, £100,000, and then authorise the Post Office to carry out this work, which they are perfectly competent and willing to do. The thing would then be done, and a standing disgrace to England as the first naval Power of the world, which yet cannot take the simplest telegraphic precautions for safety of her ships, would be removed. We should like to ask what are the Institution of Electrical Engineers doing in this matter. At one time they were all telegraph engineers, with an energy to overcome all difficulties—technical and financial. What, we may ask, is the organ of the telegraph and submarine cables doing to stir up the authorities to tackle this problem, and that not less important, the establishment of underground land lines. Let the Institution of Electrical Engineers, the London Chamber of Commerce, and the Plymouth Chamber of Commerce put their heads together and bring in a Bill for the purpose so defined and so thoroughly needed. This should command the sympathies of everyone—Press and members of Parliament, alike with men of business the kingdom over, and no time should be lost in putting the matter into practical form.

SYDENHAM ELECTRIC LIGHT STATION.



DETAILS OF EXHAUST PIPES AND WATER HEATERS. Scale ½in. to one foot.

THE CRYSTAL PALACE EXHIBITION.

According to our usual practice, we visited the majority of stands on Wednesday in order to ascertain the prospects of readiness for the private Press view, held to-day (Friday). In many instances the exhibits will be quite ready, in others partially ready, but alas! in many, the unpreparedness must lead to considerable delay before the stands are complete. No doubt a vast amount of final preparation will be got through between the time of our visit and the actual opening. The Machinery Annexe seems to be the most backward, yet there will be plenty of material for the visitor to examine from the moment of opening. Commencing a rapid survey from the north end, it was seen that the elaborate screen of incandescent lamps erected by the Edison-Swan Company, and which will be one of the greatest attractions of the exhibition, was in a forward state. Just below this screen is the large and varied exhibit of the Postmaster-General, comprising the historical and present-day apparatus used in telegraphy. Almost the whole of the exhibits are now in position. Close by is the exceedingly pretty stand of the Mining and General Company—a study in black and red—the exhibits upon which we understand will be quite ready. Mr. White, of Glasgow, has a splendid display of Sir W. Thomson's measuring instruments, fully complete. Messrs. Nalder Bros.' stand in the same quarter is ready, but not fully equipped. Still, the show of their make of instruments should be a good one. Messrs. Evered, of renown in the production of artistic fittings, have nearly completed their exhibit, as have Messrs. Joel and Co.; while the W. T. Henley Company and the Fowler-Waring Cables Company, exhibit cables and wires of varied descriptions.

One of the most interesting features of this exhibition as showing the development of telephone enterprise, will be the concert-room of the National Telephone Company, where on payment of a small fee the public will have the opportunity of listening to the music which is being performed at theatres in London, Birmingham, Manchester, and Liverpool.

It must be allowed that the National Telephone Company and the Western Electric Company adjacent have two of the best-arranged stands, and should be quite ready at the opening ceremony. Of the large engineering firms, Woodhouse and Rawson, Crompton, the Brush Company, Siemens Bros., and Messrs. Johnson and Phillips, come one after the other, and each of these stands will have sufficient apparatus of interest to make a good show, though it is perfectly evident some of them will not be completely ready at the opening. The General Electric Company will have some very effective exhibits, but we deem it preferable not to enter upon detailed description till the exhibition is fairly opened. Our readers require a little more information than a mere catalogue list. Many of the smaller stands at the sides of the Central Nave will be quite ready, and will fully exhibit the specialities of the various manufacturers. Altogether the exhibitors may be congratulated upon the vast amount of excellent work put in since the commencement of the New Year, but even the extra week's grace has not brought about that completeness which the public look for and expect.

A visit to the galleries on Wednesday last showed that considerable progress has been made since last week, and that, though a good deal still remains to be done, some of the stands will be in a fair way to completeness by next week. We doubt, however, that several weeks must elapse before the odour of paste and polish tones down. The idea of exhibiting examples of living-rooms, conservatories, and so on, furnished and decorated in various styles is excellent, and marks the advance that has been made in practical electric lighting since the 1881 exhibition. It also shows that decorators and upholsterers are fully aware of the advantages offered by the incandescent lamp, for here we find two such firms combining to exhibit their wares under its light. We are afraid, however, that the desire for more light, which has been growing steadily during the last decade consequent upon the introduction of electric lighting, is likely to lead to error. Whilst it is perfectly true that we want more light in our streets, stations, and large buildings—and since electric lighting led the way and educated the public, have, to a certain extent, got it at the hands of the electrical or gas engineers—it does not follow that the object of introducing incandescent lamps into our houses is to obtain more light. It has been repeatedly pointed out that to have too much light in a room is almost worse than not to have enough. The reasons why we use electric lights are because they are cleanly, and do not injure costly decorations, because they do not vitiate the air, and because they can be placed exactly where we want them. There is a flexibility about the incandescent light which is wanting in all other systems of illumination. Now, this being so, we think it will be a pity if the various firms who are exhibiting interiors go in for demonstrating the illuminating power of the electric light rather than its flexibility and adaptability. We don't want to see floods of light in these model rooms, but we want to see them really well lighted—that is, to find the light just where it is required. For instance, we very much fear that one of the dining-rooms exhibited is to have a lamp depending from every square yard of the ceiling, the wires coming through certain projections in the decoration. If this is the intention we think it will be a mistake. True, the room will be flooded with light reflected downwards by the white ceiling, but there will be too much of it, and the method of its introduction is not to be commended. Every room requires to be lighted in a different way, because each is used for a different purpose, and we hope this fact will be fully recognised at the Palace, and, as we have said above, the beautiful adaptability rather than the illuminating power of the incandescent lamp brought before the public with marked emphasis. But to chronicle the progress made since our last visit. The stand of Messrs. Rashleigh Phipps, and Dawson is rapidly nearing completion, and one can get a fair idea of the appearance which the rooms will have when the finishing touches have been put to them. In the conservatory the rockwork is in evidence, and this should prove quite a favourite spot for visitors, as it will command a kaleidoscopic view of the main floor below. The Old English hall, Italian dining-room, and Japanese drawing-room have all taken on form and colour, and a few days now will make a wonderful difference in their appearance.

MESSRS. H. AND J. COOPER, of Great Pulteney-street, are also well forward with their dining-room, bedroom, and boudoir. The latter should afford many opportunities of showing what can be done with the incandescent lamp. Many ladies are halting between two opinions in the matter of electric lighting. They are weighing the disagreables of "wiring," which they, and especially their sterner halves, place in the same category with "spring cleaning," "papering and plastering," etc., against the advantages which will accrue from turning out the gasman and bringing in the electrical engineer. Nothing will give the balance a kick in the right direction more quickly than the sight of a well lighted and cosy boudoir. This, no doubt, Messrs. Cooper will take care to provide them with.

MESSRS. ALLEN AND MANNOOCH, of Mount-street, Berkeley-square, W., are working hard to complete their exhibit, which includes a dining-room, with dark oak furnishing and panelling, a bedroom and a boudoir. These rooms will no doubt attract considerable attention when they are finished We hope, however, that the firm will not try to overdo the lighting. Too many lamps, like too many cooks, sometimes spoil the best of—intentions.

Mr. GILES, of High-street, Kensington, has a large stand which is in a fairly forward condition. It will comprise a suite of rooms designed to show what he can do in the way of decorating and furnishing.

Mr. C. B. HARNESS'S gorgeous temple, wherein he will 'tice the B.P. after the manner of the nursery rhyme, was filled with paperhangers and decorators at the time of our visit, and will no doubt subsequently be crammed with the believing. A huge signboard close at hand indicates that this is the way to the camera obscura. Mr. Harness's temple has been designed, and excellently well designed too, by Messrs. Benison and Bargman, architects, of 16, Craven-

street, Strand, and has been put up by Mr. E. Triggs, builder, of 95, The Chase, Clapham, S.W.

In close proximity to this stand is a suite of rooms which are being decorated and furnished by MR. W. POOLE, Church-road, Upper Norwood, and MR. ELDRIDGE, of Westwood-street, Upper Norwood, the two, although trading separately, having, we understand, combined to exhibit their different wares under the soft rays of the electric light. The suite will be very complete, and will comprise hall, dining-room, drawing-room, bedroom, boudoir, and bathroom.

Close at hand, MESSRS. SHIPPEY BROS. are making a special feature of American goods, and will show lamps and motors in a hundred and one different shapes and sizes, whilst giving practical illustrations of the many uses of the latter. We are also promised something novel in the shape of devices for attracting the public, but of these we shall be able to say more when the promise has been fulfilled, as no doubt it will.

ELECTROLYSIS OF GOLD SALTS.

BY ALEXANDER WATT.

(Continued from page 17.)

It should be mentioned that many of the solutions of gold salts prepared for use in these experiments were of an exceedingly unstable character, some of them being very readily decomposed by light, in some cases being reduced to the metallic state, often in a more or less crystalline form; while from some of the solutions prepared from the teroxide the metal deposited in the form of protoxide soon after the solutions of the persalt had been effected. This separation of the protoxide occurred in some instances when the solution of the persalt had been obtained without the aid of heat, but more readily so when the respective liquids were heated. In such cases, therefore, it was found necessary to electrolyse the solutions of the unstable salts referred to almost immediately after their preparation—that is, during the brief period that the metal remained in solution.

12. *Aurochloride of Sodium by Electrolysis.*—A strong solution of chloride of sodium was electrolysed with the current from three cells, a gold anode and silver cathode being used as before. Chloride of gold at once formed at the anode, and in a few minutes after a deposit of gold was received upon the silver plate.

13. *Aurochloride of Potassium.*—A solution of chloride of potassium, being electrolysed with the same current as above, yielded a deposit of gold upon a silver cathode in a few minutes after immersion.

14. *Aurochloride of Magnesium.*—A solution of chloride of magnesium under the same conditions as above rapidly dissolved the gold anode, and a deposit of the metal was received upon a silver cathode in two or three minutes after the electrodes were immersed in the liquid.

15. *Aurochloride of Barium.*—A solution of chloride of barium, being electrolysed with the current from three Daniells, dissolved the anode freely at once, and a deposit of gold formed on a silver cathode in a few minutes after.

16. *Aurochloride of Strontium.*—A solution of chloride of strontium, electrolysed under the same conditions as before, yield a solution of gold, from which the metal became deposited upon a silver cathode in a few minutes after immersion of the electrodes.

17. *Teracetate of Gold.*—A solution of this salt was formed by digesting moist hydrated teroxide of gold in ordinary commercial acetic acid; a small portion only of the oxide became dissolved. The solution, after being moderately diluted with water, was electrolysed with the current from four Daniell cells, when a deposit of gold slowly formed upon a silver cathode. After a few minutes, green non-reguline metal formed upon the film first deposited.

18. *Tersulphate of Gold.*—Hydrated teroxide was digested ? dilute sulphuric acid, and the resulting solution was electrolysed with the current from three cells in series. After a rather long immersion, a film of gold gradually formed upon a cathode of silver; the amount of gold in solution was, however, small, and there appeared to be no action upon the gold anode.

19. *Terlactate of Gold.*—In some former experiments in the electrolysis of metallic salts the writer had found that lactic acid exhibited a higher solvent power for metallic oxides and carbonates, and even upon some metals, under electrolysis, than could have been expected from so comparatively weak an acid. This fact induced him to ascertain the behaviour of this acid in respect of gold. A strong solution of lactic acid being prepared, a portion of this was added to a quantity of moist hydrated teroxide of gold, and the mixture repeatedly stirred for a few minutes. The mixture was then placed on a filter, and a portion of the clear liquid, which had a purple tint, was afterwards tested with a solution of chloride of tin, when the purple of Cassius at once formed, indicating the presence of gold in the solution. The clear solution was then electrolysed with the current from three Daniell cells in series, a gold anode and strip of platinum foil being used as the electrodes. Soon after the circuit was completed, a dark green film appeared upon the platinum, while the anode, which at first presented a rather dull surface, became somewhat brighter. The green deposit, which, as before stated, represented gold in a finely-divided (and non-reguline) state, was next heated by holding the platinum foil on which it was deposited over the flame of a spirit lamp, when after a few moments the gold film assumed the more perfectly metallic state, but apparently in two different conditions—one part of the film assuming the characteristic colour of fine gold, but the remaining portion (at the lower part of the cathode) was of a deep orange-red colour. The gilt portion of the platinum was next dipped into warm nitro-hydrochloric acid, when the yellow part of the film readily dissolved, but the orange-red portion was very tardily acted upon, and fell from the plate in small grains of a deep red colour.

20. *Lactate of Gold by Electrolysis.*—An attempt was next made to determine whether lactic acid, under the influence of the current, would act upon the gold anode, forming a solution of gold from which the metal could be deposited. For this purpose, a strong solution of lactic acid was electrolysed with the current from four cells, when in about a quarter of an hour or so a green film appeared on the silver cathode as before, proving that the anode had been somewhat speedily acted upon by the acid. A platinum cathode was next used, which received a yellow film of gold shortly after immersion.

21. *Purple of Cassius by Electrolysis.*—A rather weak solution of protochloride of tin was electrolysed with the current from two cells, a gold anode and silver cathode being used. Almost immediately after immersion of the plates, the purple of Cassius formed at the anode, and gradually deposited somewhat copiously at the bottom of the vessel. This method of producing the purple salt might be found useful.

22. *Terchloride of Gold in Hydrochloric Acid.*—A solution was prepared by dissolving gold in aqua regia and carefully evaporating the terchloride to dryness. A portion of the dry gold and salt was then dissolved in hydrochloric acid. The resulting solution was afterwards considerably diluted and electrolysed with the current from a single Daniell cell. A silver cathode immersed in the liquid received a deposit of gold of very good colour very promptly, the film being firmly adherent. It is not improbable that a solution thus composed might be found useful for some purposes, if worked with care. The liquid, however, must be weak and the current low.

23. *Teroxide of Gold in Nitric Acid.*—Teroxide of gold was digested in dilute nitric acid, and the solution, after being diluted, was electrolysed with the current from three cells. Gas was given off at both electrodes, and metallic gold deposited upon the silver cathode.

24. *Saccharate of Gold by Electrolysis.*—A strong solution of saccharic acid was electrolysed with the current from four cells, when the gold anode became very slowly

dissolved, and in about half an hour a film of gold of a grey colour formed upon a platinum cathode, which readily dissolved in aqua regia. A silver cathode was next substituted, upon which the metal deposited of the characteristic yellow colour of gold at first, but after a time the film acquired a somewhat dirty colour, indicating the pressure of non-reguline metal—probably the *grey* condition before noticed.

25. *Electrolysis of Bisulphate of Potassium.*—A solution of the bisulphate was electrolysed with the current from four cells, a gold anode and silver cathode being used. Gas was liberated at both electrodes, and in the course of about half an hour, or somewhat less, a slight film of gold appeared upon the silver surface.

26. *Aurate of Ammonia in Lactic Acid.*—A solution was prepared by dissolving aurate of ammonia in a strong solution of lactic acid. The solution, after being moderately diluted, was electrolysed with the current from a single cell, when gold of good colour at once became deposited upon a silver cathode.

27. *Gold Teroxide in Tartaric Acid.*—Hydrated teroxide of gold was digested in a strong solution of tartaric acid for some time, and the liquid, after being moderately diluted, was tried with the current from three cells. Gas was evolved at both poles, and a slight film of gold slowly formed upon a cathode of silver.

28. *Electrolysis of Phosphoric Acid.*—A strong solution of phosphoric acid was electrolysed with the current from four Daniells. In about half-an-hour after immersion of the plates it was found that a deep orange-red salt had formed on the anode, which fell from the plates in transparent flakes. A slight film of metallic gold deposited on the silver cathode.

29. *Electrolysis of Vanadiate of Ammonia.*—A strong solution of vanadiate of ammonia was electrolysed with the current from three cells, when after a short time the (colourless) solution acquired a rich yellow colour. At the bottom of the vessel minute crystals of a deep red colour appeared, and gold of a green colour and non-adherent formed upon a platinum plate. This deposit when moderately heated assumed a yellow colour. A silver cathode being substituted, this slowly received a slight film of reguline gold of the usual colour.

30. *Teroxide of Gold in Phosphorous Acid.*—Teroxide of gold was digested in a strong solution of phosphorous acid, and the solution, after being filtered, was electrolysed with the current from four cells. A very slight deposit of gold formed on the cathode, but a long immersion failed to yield a film of any thickness.

31. *Electrolysis of Phosphorous Acid.*—A strong solution of phosphorous acid was electrolysed with the same current as the last, and after a rather long immersion, a silver cathode became slightly coated with a film of gold. On examining the anode the immersed surface was found to be coated with a deep orange-coloured salt, which separated in transparent flakes, much resembling both in colour and appearance the flaky film referred to in experiment 28, and in several other experiments.

32. *Electrolysis of Chlorate of Potassa.*—A moderately strong solution of chlorate of potash was electrolysed with the current from three cells. Gas was given off at both electrodes, but otherwise there was no apparent action for some time; after a few minutes, however, it was observed that a profuse quantity of flat scaly crystals floated on the surface of the solution. On examining the anode at this time, it was found to be coated with a bright blue film, which was insoluble in the liquid.

33. *Electrolysis of Hydriodic Acid.*—A solution of hydriodic acid being prepared, it was determined to ascertain if it would dissolve gold from the anode by electrolysis. For this purpose the current from two Daniells was first tried, when the liquid nearest the anode at once assumed a yellow colour, but as there was no deposit of gold upon the silver cathode a third cell was put in series, soon after which black flakes fell from the anode and deposited at the bottom of the vessel. On examining the cathode at this time it was found to be coated with pale straw-coloured gold.

34. *Gold Teroxide in Hydriodic Acid.*—Moist hydrated teroxide of gold—obtained by adding a solution of potash to the terchloride—was digested in a strong solution of hydriodric acid, in which it dissolved rather freely. The solution thus obtained was electrolysed with the current from three cells, when a deposit of green, non-reguline gold formed upon the silver cathode at once; when this loose deposit was wiped off with the finger, a film of yellow reguline metal was found beneath, as is frequently the case when the green form of gold is deposited. To prevent the formation of this variety of the metal, and to obtain a fully reguline film, the solution was diluted and one cell disconnected from the series, when the metal deposited in better condition, but more especially when the cathode was gently moved about in the solution.

35. *Electrolysis of Iodide of Sodium.*—A solution of iodide of sodium was electrolysed with the current from three cells, when the liquid nearest the anode immediately acquired a yellow colour. The operation was then left undisturbed for about 10 minutes, at the end of which time the cathode was examined, when it was found to be coated with a film of gold in the green, non-reguline condition.

36. *Electrolysis of Iodide of Ammonium.*—A solution of this salt, electrolysed under precisely the same conditions as in the last experiment, soon acquired a yellow colour, and the cathode, as before, was coated with a film of green, non-reguline metal. When the solutions in this and the last trial were diluted and the current reduced, the gold deposited, though somewhat slowly, in the yellow, reguline state.

37. *Gold Teriodide in Hyposulphite of Soda.*—Hydrated teroxide of gold, precipitated by potash from the terchloride, was digested in a solution of hyposulphite of soda, and the resulting liquid electrolysed with the current from three cells. A film of gold, of a good rich colour, and firmly adherent, was promptly deposited upon a silver plate.

38 *Gold Teroxide in Citric Acid.*—Hydrated teroxide of gold was digested in a strong solution of citric acid, and the liquid, after filtration, was electrolysed with the current from three cells. Gas was freely given off at both electrodes, and after a few minutes' immersion a slight film of gold appeared upon a silver cathode. The amount of metal in solution was, however, very slight, and there was no apparent solvent action upon the anode.

39. *Gold Protiodide in Pyrophosphate of Soda.*—Iodide of gold was digested in a strong solution of pyrophosphate of soda. The current from four cells was found necessary to obtain a deposit upon a silver plate, and this only assumed the form of an iridescent film. Gas was given off at both electrodes. On heating the plate to near redness the film still retained its iridescent character, but the colourations were rendered more vivid and brilliant by the heat to which they had been subjected.

40. *Teroxide of Gold in Benzoic Acid.*—The precipitate thrown down by carbonate of potassa from a solution of gold terchloride, and the mixture afterwards boiled, was digested in a hot solution of benzoic acid, and the still warm solution was then electrolysed with the current from four cells. Gas was evolved at both poles, and a slight film of gold, of a yellow colour, was deposited upon a silver plate. A fifth cell was afterwards added to the series, when the deposited gold assumed a dark colour.

41. *Teroxide of Gold in Malic Acid.*—The teroxide precipitated by carbonate of potash, and treated as before, was digested in a strong and warm solution of malic acid. The solution was then tried with the current from three cells, but there being no apparent action, a fourth cell was added, when gas was liberated at each electrode, and a dark—almost black—film formed upon the silver cathode, which was very adherent. When heated over the flame of a spirit lamp, the film became iridescent, but when the surface was rubbed yellow gold appeared attached to the silver beneath.

(To be continued.)

REPORT ON TRIALS OF A 100-UNIT PARSONS STEAM TURBINE DYNAMO AT HEATON WORKS, NEWCASTLE-ON-TYNE.

BY PROF. EWING, F.R.S.

The machine tested in December last is, I am informed, the first condensing steam turbine that Mr. Parsons has built. Its shaft was designed to carry six small and one large plate or disc, each fitted with a series of rings of turbine blades, the large plate being specially designed to deal with low-pressure steam. After passing it, the steam was exhausted into a jet condenser of novel design, the pump of which was driven by a separate donkey engine. The turbine rings were of the outward flow type.

The turbine was designed to work with steam at an initial pressure of 140lb. per square inch, but on the occasion of the trials it was not practicable, for want of a suitable boiler, to use a pressure of more than 95lb. per square inch. The first and second plates with their turbine blades were accordingly removed, and the tests were made with the remaining four small and one large plate. The effect of this was to make the results of the trials less favourable, as to economy in steam consumption, than they would have been had the full initial pressure of 140lb. been available.

In line with the turbine shaft, and directly coupled to it, was the armature of an alternate-current dynamo capable of yielding 100 kilowatts, or 100 Board of Trade units of electrical energy per hour, and wound for a potential of 2,000 volts. The exciter was a distinct small dynamo of the continuous-current Gramme type, which was also mounted on a prolongation of the turbine shaft.

The turbine ran at a speed of about 4,800 revolutions per minute, and the armature was wound with a single coil, so that the frequency of the alternations was about 80 complete periods per second.

The whole machine, comprising the turbine, dynamo, and exciter, weighed about four tons; its length was about 14ft., and its greatest breadth barely 3ft. It stood on three cast-iron pedestals resting on an ordinary concrete floor. There were no holding-down bolts or special foundations, and none seemed to be required. The machine ran almost without vibration.

In the trials the current generated was spent on a bank of resistance coils consisting of open spirals of iron wire strung on wooden frames. The output was varied, in successive trials, from about 20 units per hour, or, say, one-fifth load, to 100 units per hour or full load. The loads spoken of are the amounts of electrical power spent in the external circuit, and do not include the work done by the exciter in supplying current to the field magnets of the main dynamo. (The output of the exciter was about 2½ units per hours.)

In two additional trials there was no external load beyond what was necessary for measuring the potential.

The experiments were arranged to give complete information of the amount of steam used by the turbine under all grades of output from full load to zero.

The electrical output was taken to be the product of the effective volts at the dynamo terminals into the effective amperes. The volts were measured by aid of a 2-h.p. transformer, which transformed down in the ratio of 1 to 10, and a pair of Cardew voltmeters. To test the accuracy of the professed ratio of transformation, the volts were on one occasion read by applying a Cardew voltmeter to successive portions of the bank of resistance coils (then grouped in series), so that the potential was directly determined by summing up the readings. This determination was found to agree exactly with that obtained by means of the transformer.

The Cardew voltmeters were themselves tested by comparison with a third Cardew, which in its turn had been standardised by help of one of Sir William Thomson's balances. They were found to be correct.

The current was measured by (1) an Evershed gravity ampere meter, and (2) a Siemens electro-dynamometer. These were connected in series in several of the trials, and found to be in perfect agreement. The Evershed ment had been tested against a Thomson balance.

The consumption of steam in the turbine was measured by passing the feed-water through a measuring tank, the capacity of which I checked. Steam was supplied from an old boiler of the locomotive type at a pressure of 90lb. to 95lb. per square inch. The steam-pipe was too small, and the loss of pressure between the boiler and the turbine must have been considerable, especially in the full-power trials.

In the full-power trials this boiler was insufficient to supply all the steam, and another boiler was joined to it. It was then impracticable to measure the feed, and the amount of steam passing through the turbine was estimated in these trials by measuring the rise in temperature of the water discharged from the condenser, in conjunction with the amount of the water, as gauged by means of a weir. This rise in temperature and the head over the weir were noted in all the trials, so that when the feed was directly measured a constant was determined which could be applied in cases where a direct measurement of the feed was impracticable.

The boiler was old and leaky, but the amount of water which fell to be deducted from the whole feed on this account was repeatedly determined. The allowances made for leakage are certainly not excessive, and do not in any case affect the full-power trials materially.

The steam required for (1) the feed-pump, (2) the air-pump, was supplied by a separate boiler, and is not included in the quantities that are stated below.

The vacuum ranged from 28½in. at light loads to 26½in. at full load. The temperature of the cold well varied from 5deg. C. to 18deg. C.

The trials extended over three days—December 12th, 14th, and 15th, 1891. The turbine was kept running, without change of load, long enough in each case to secure a uniform regime, and to prevent any material error from being caused by an inexact reading of the water-gauge glass on the boiler. The machine ran without any hitch throughout all the trials.

The following are the observed results. The trials distinguished by an asterisk are those in which the consumption of steam was inferred from the rise of temperature in the injection-water. In the other trials it was measured directly, as feed-water.

Electrical output in units generated per hour.	Steam used in the turbine in pounds per hour.	
0·3	510	492 (mean)
0·3	475	
20·8	1,120	
31·2	1,350	
48·5	1,875	
65·9	2,460*	
66·5	2,580	
93	3,530*	
100	3,600*	

These results are also shown graphically in the accompanying curve, which shows the relation of the number of pounds of steam used by the turbine per hour to the number of electrical units generated per hour.

It is convenient also to express the results in another way, by stating the number of pounds of steam used per unit generated, at various rates of output from full load downwards. These quantities, obtained by measurement from the curve, are given in the following table:

Output in units per hour.	Number of pounds of steam used per unit.
10	77½
20	53
30	43
40	41
50	39
60	38
70	37½
80	37
90	37
100	37

It will be seen from these figures that the consumption of steam by this condensing turbine was 37lb. per electrical unit generated, when the machine was giving its greatest output; that the output might be reduced to, say, three-fourths of its greatest value without causing any sensible addition in the consumption of steam per unit; and that at half load the consumption was 39lb per unit. When the load is further reduced the consumption per unit increases,

as it does in all engines, on account of the work which is expended within the machine itself.

The consumption of 37lb. per unit at full load corresponds to 27·6lb. per electrical horse-power per hour; and the consumption of 39lb. per unit, at half load, corresponds to 29lb. per electrical horse-power per hour.

For the sake of comparison it may be added that in a good ordinary compound condensing engine of corresponding power the consumption of steam is usually about 20lb. per indicated horse-power per hour, which corresponds (allowing for necessary loss in transmission to the dynamo) to, say, 36lb. per unit. In the special type of single-acting high-speed engines made by Mr. Willans, and successfully used in many electric light stations, the consumption of steam at full load and at moderately full load is somewhat less. The best results in trials published by him show (with high pressure and triple expansion) a consumption equivalent to about 30½lb. per unit in a non-condensing engine and 25lb. per unit in a condensing engine, worked at full load; while at half load the numbers are about 43lb. per unit and 32lb. per unit respectively.

I have no doubt that if it had been practicable in the turbine tests to use the full pressure of 140lb. per square inch for which the turbine was designed (in place of a pressure of 95lb.) that the consumption of steam per unit would have been considerably reduced.

As they stand, however, the results must be admitted to demonstrate a very remarkable performance. They show that in respect of economy of steam, and therefore of fuel, at full or moderately full load, the Parsons turbine of the type and size tested now challenges comparison with good engines of the usual kind, while its comparative freedom from friction gives it an exceptionally high efficiency when lightly loaded.

Apart from the question of steam economy, the lightness and compactness of the turbine dynamo, its small first cost, the perfect ease with which it is started, its freedom from vibration, and the absence of any need for heavy foundations, are points much in its favour as a generator for central station work.

Mr. Parsons has been good enough to give me every facility for examining the construction of his turbines and dynamos. I see no reason to anticipate that the charges for maintenance, for oil, and for attendance will be larger than in the case of other engines I should rather expect them to be lighter, and this appears to be borne out by the experience of the Newcastle and District Electric Lighting Company, where turbine generators have been in use for about two years.

I had the advantage of seeing the plant at that company's station and of obtaining particulars in regard to wages and other items of current outlay from the superintending engineer and the secretary of the company, who were most willing to supply information.

In regard to first cost, the turbine generator is probably cheaper, in large sizes, than any combination of ordinary engine and dynamo giving equal output.

The machine tested had an electrical governor which regulated by causing intermittent admission of steam. The action of this governor was not entirely satisfactory, and Mr. Parsons informed me that he meant to substitute for it a modified form of a type of governor which has been found to work well at the Newcastle and district electric light station and elsewhere.

The turbine worked at its full load of 100 electrical units per hour without any sign of distress, and so far as could be judged was capable of giving a greater output without difficulty. The dynamo armature became hotter than is, in my opinion, desirable. This might be avoided by an alteration in the winding of the armature.

With a dynamo wound to give continuous currents, the consumption of steam in the turbine per electrical unit generated may be confidently expected not to exceed the consumption observed in these experiments.

GREENWOOD'S ELECTRO-CHEMICAL PROCESS.

A new process for the direct production of caustic soda and chlorine has been devised by Mr. J. Greenwood, and is now being introduced by the Caustic Soda and Chlorine Syndicate, Limited, of 58, Lombard-street, E.C. It has this week been inspected in operation by a number of gentlemen at the works of Messrs. Bowes Scott and Weston, Phœnix Wharf, Battersea. The passing of an electric current through a solution of common salt divides the latter into caustic soda and chlorine, but the principal difficulty hitherto encountered in placing any method of this kind on a commercial footing has been to prevent the recombination of the electrolysed products. It is claimed, however, that the inventor of the process in question has surmounted this obstacle by the use of a patent diaphragm and a compound anode.

Mr. W. H. Preece, who has made experiments with the plant, states that the commercial efficiency of the process is 75 per cent., and he is certain that in actual practice, and with further experience, even better results can be obtained. As far as the expense of producing electrical energy is concerned, he says that in the coal districts, with triple-expansion modern engines and dynamos, working continually at full load, the cost would amount to ⅛d. per kilowatt hour. The total cost of producing caustic soda and bleaching powder and liquor would, according to Mr. Preece, be little more than one-third of their present market value.

Dr. Gore, F.R.S., has drawn up two reports. He states that he is convinced of the scientifically practicable character of the method, and that nearly all the chief engineering chemical difficulties of the process appear to him to have been overcome. He also expresses the opinion that the amount of labour and the number of workmen necessary in the process, when carried out on a large scale, would probably be small in comparison with that required for producing the same quantities of the same products by the usual methods, because the entire process would be largely automatic.

Messrs. Cross and Bevan, of the laboratory, 4, New-court, W.C., find that the efficiency of the process has advanced to 80 per cent., as compared with 70 per cent. when preliminarily examined by them some months ago.

The plant laid down consists of five electrolytic tanks arranged in the form of a flight of steps, whilst the vessel containing the supply of brine is erected on a higher level than the top tank. This arrangement ensures an automatic circulation of the solutions. Each tank contains five compound anodes and six cathodes placed alternately, these being separated by diaphragms. The anode is formed of carbon plates having a metal core so as to increase the conductivity; it is specially treated so as to render it non-porous and unattackable by the chlorine gas which, it may be mentioned, is evolved on its surface. The cathode, on which is formed the caustic soda, is an iron plate. The patent diaphragm is of peculiar construction, being composed of strips of slate arranged in a longitudinal frame. These strips are placed at an angle of about 45deg., one above the other and on each side of the frame, an intermediate packing of asbestos fibre being used. The diaphragm and the anode constitute the two principal features of the process.

Each tank is divided into 10 anode or chlorine sections, and 10 cathode or caustic soda sections. The anodes and cathodes in each tank are arranged in parallel, and the five tanks in series. An E.M.F. of 4·4 volts, with a current of 10 amperes per square foot of electrode surface, is required to overcome the resistance of each tank. Vulcanite tubes are employed to connect the 50 anode sections, the inlet being at the bottom and the outlet at the top of each section. The cathode sections are similarly connected.

The working of the process is, briefly, as follows: The tanks are charged with a solution of common salt, and on a current being passed the solution is decomposed or divided into its constituents, chlorine and sodium. A secondary action occurs in the separation of the sodium, and this converts it into caustic soda. After passing out of the lowest tank the salt solution and the caustic soda are pumped back to their respective charging vessels, the former to be further decomposed and the latter to be further concentrated. The chlorine gas given off in the anode sections passes by means of branch and main pipes into four absorbing tanks. These contain lime and water kept in a state of agitation and which takes up the chlorine and transforms it into bleaching or chlorate liquor as required. The caustic soda formed in the anode sections is rendered more or less concentrated according to the particular purpose for which it is required.

The company state that the process will be of great importance to the paper, soap, and bleaching industries, and that it is also applicable to the production of sodium amalgam and chlorine for extracting gold and other metals from their ores, and caustic and chlorate of potash and other chemicals. This brief description of Mr. Greenwood's process is given, as the lawyers say, "without prejudice." So many processes have from time to time been put forward, and have failed, even when reported upon by the highest authorities, that a considerable amount of caution must be used. A process may be theoretically perfect, and seem commercial upon an experimental scale, though, when tried upon a large scale, it proves to be less successful.

Tudor Accumulators.—The Tudor Accumulator Company have issued an illustrated catalogue of some pretension. Besides information as to size and prices, chapters are given, one containing the reports on these accumulators by MM. Uppenborn, Kohlrausch, and Monnier, and others, and the other dealing with best methods of mounting accumulators. Directions for the care and management of the cells are given in a special chapter.

THE

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CONTENTS.

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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1892.

It is usual at the commencement of each new year for the Queen to honour those in her realm to whom the Prime Minister for the time being believes honour to be due. Such honours are conferred for various reasons—mostly political. At times, however, other claims are held to be paramount, and the scientific world contributes its quota to those who receive these honours.

Few announcements will give more pleasure to the scientific world in general, and the electrical world in particular than, the announcement that a peerage is to be conferred on Sir William Thomson. In his person no one can complain that scientific pre-eminence is not rewarded, though it would indeed be difficult to add distinction to that he has himself achieved by his numerous practically useful inventions and deep mathematical researches. Elected President of the Royal Society last year, the highest purely scientific honour a native of the United Kingdom can receive, his elevation to the peerage is only a further step in his distinguished career. We have no need to allude to Sir William Thomson's achievements in science—they are too well known to our readers to require iterated mention, but we do not think his kindness and interest in struggling students, of whom he must have had an enormous number under his charge, has been brought to light. We remember one interesting example which will bear mention at this juncture, and illustrates the kindness of two men and the influence a little help will have upon a young man's life. The late Dr. Royston Piggott, who died recently at Eastbourne in the fulness of ripe age, was in early years Sir William's mathematical tutor, and kept his interest in his distinguished scholar. Dr. Piggott was always interested in promising young students, and one of his *protégés* was the son of a policeman who had taken to amateur electrical experiments. The doctor learnt of this, gave the lad lessons, and then asked the father whether he wished his son to be made an electrician. The father did not seem anxious for honours, but the mother was, and, armed with a letter of introduction to Sir William Thomson, she posted to Glasgow with the boy and a heap of electrical instruments. Sir William was not at home, but visiting at a country house in the neighbouhood. Not to be daunted, the hopeful mother took a cab, and, with the seat crowded with instruments, called at the house, and asked for Sir William, who came down from the billiard-room with a cue in his hand. With much amusement and interest he interrogated the couple, and finally made an appointment at the college in Glasgow, and found the boy a place. It is many years ago now, but this young man, we believe, soon after received an appointment as superintendent of telegraphs in one of the colonies, at a salary of some £600 a year—rather better than he might have hoped for in his native town. Numerous other cases might be quoted to show that

Sir William feels an interest in human as well as scientific problems. Nor have we probably heard the last of his contributions to the latter. It is possible, we hear, though not yet decided, that the title which Sir William will take will be that of Lord Kelvin, from the name of the once beautiful river which flows past the foot of the college grounds at Glasgow, and on which his windows look out. May he live long to enjoy his honours!

In our next issue we shall give a further series of portraits similar in style to those given in our last number. As far as possible our publisher will refuse to supply single copies of these special issues to casual purchasers. We do not cater for those who pick up an odd number of the paper now and again, but desire to do the best to provide suitable pabulum for those who are regular readers.

If in our issue of January 2, 1891, we felt constrained to say "the business problems that await solution to-day . . . are very similar to those awaiting solution a year ago," we should not be far from correct in restating that view. Yet there is a great difference in January, 1892, over January, 1891. Financiers were still very shy in 1891; they are still shy, but less so, because month by month electrical engineers are demonstrating the certainty and the suitability of electric lighting for general work. Then the great experiment of Lauffen-Frankfort—whatever may be the economical figures connected therewith—the great experimental departure of the year, has forced attention from those still inclined to scoff at the probabilities of electrical applications. English electricians have sadly attempted to belittle the adoption of polyphase apparatus. In public and in private they have denied there was anything good in the idea, but they find their continental and American *confrères* refusing to see in the same light. Let us admit that we have still much to learn about polyphase apparatus, and await further experimental and theoretic study before condemning the departure.

FINANCIAL.—Whether the future will see rotary-current apparatus pass into oblivion or develop into greater prominence, there can be no doubt it has proved the grandest advertisement for electrical engineering that the past year brought forth. It has helped other and more modest work in the eyes of the financiers, so that at the present time more than one energetic firm or company finds it less difficult to finance its new schemes than was found twelve months ago. It would not be right, however, to hint without qualification that "finance" was now easy, and would continue so. There are troubles looming ahead connected with companies whose prospects are thought to be bright. Long ago we suggested investment in low-priced shares—such as the Brush were then quoted—to some higher-priced ones. The market quotation is not always an indication of real value; there is such a thing known as making a price. We again reiterate in the strongest possible manner, avoid the highest prices and be content with the lower. With the exception that it makes financing difficult, we care little what the public gains or loses in its buying and selling shares. The public has no sympathy with those who correctly advise, and, on the other hand, the adviser often cuts his own throat by making enemies of those who are willing to pay for silence. The smash up of a big company, however, is harmful to the industry generally—hence our warning. There are few or none of the existing concerns past recall, and most of them with a moderate amount of care will prove good investments.

TRACTION.—The event of the year, so far as England is concerned, has been the installation of the Thomson-Houston overhead system of trams at Leeds. We gave a very complete description of this line at the time of the opening, and the experience of our friends living in the district is altogether in favour of the line. At the time of the opening ceremony we attempted to get the views of residents on the route, but, like most Yorkshiremen, they refused to commit themselves. A few days since, testimony unasked for was forthcoming, and, as we say, altogether in favour of the line. No doubt Mr. Graff Baker has had similar testimony from a number of people, but this outside praise cannot be unacceptable. The consensus of opinion being thus favourable, should lead to a rapid extension towards the centre of the town; and the success at Leeds, we trust, will induce other places to go forward. The City and South London, while it may not have fulfilled all the expectations of its promoters during its first year of existence, is undoubtedly gradually winning its way to success, and the experience gained thereon will be invaluable in the extensions to be undertaken in other quarters of London. The earliest of our electric trams—that of Mr. Volk's at Brighton—after undergoing vicissitudes of no ordinary kind, is still running satisfactorily, and is about to be greatly improved. The widening of the roadway has made it difficult to keep the rails clean enough to use one rail as a lead and the other as a return, so a third rail is to be added. Two new cars are being built by Messrs. Kerr, Stuart, and Co., which Mr. Reckenzaun will fit with motors. The other lines are much as they were. Mr. Holroyd Smith is to carry out an experiment at Halifax, and we have no doubt he will be as successful there as at Blackpool. What promises to be the great feature of the present year is the Liverpool overhead railway, the apparatus for which is being constructed at Wolverhampton.

The ACME ELECTRIC WORKS inform us that the past season has been the most successful that the firm has experienced, and the works have been fully occupied throughout the year, and, in fact, for the last four months it has been necessary to keep them going on overtime regularly. They have been favoured with a succession of orders from Government departments for heavy switchboard and other work, and have substantial current orders in hand. The present year has opened out in a very promising manner. With reference to the Teague patent electricity meter, this has now been developed into a commercial instrument, and the labours upon it

have been rewarded by important orders. The firm has considerably extended its plant in the instrument department, which enables rapidly-increasing demands to be met with facility. The new Acme patent ampere and voltmeter has turned out most successful, and has been received with much favour, and the demand for the same is steadily on the increase. The firm's well-known switches and fuses still maintain the prestige they have so long enjoyed, and business in this department is increasing rapidly.

BENHAM AND FROUD say, generally, that they have been very busily engaged in the manufacture of electric fittings of the highest class of art metal work throughout the whole year.

DRAKE AND GORHAM.—A review of the work done by Messrs. Drake and Gorham shows that country house lighting is on the increase, this firm having carried out about 50 installations, notably Wynyard Park, for the Marquis of Londonderry, 1,000 lights; Margam Castle, for Miss Talbot; Rhinefield, for Lieut. Munro; Hoddam Castle, Ecclefechan; Felstead Schools; Clatford Mills, Andover, for Mr. Forster; Adhurst St. Mary, for Mr. Bonham Carter; Shendish, for Mr. Longman; Leonardslee, Horsham, for Sir E. G. Loder; Ardoe, for Mr. Ogston; The Lodge, for Mr. de la Rue, etc. A number of houses have been wired for the supply from a central station, and the firm are carrying out work for the London County Council at the weights and measures testing station, Newington. The wiring of the Royal Colonial Institute has also been carried out by them. The Cardew patents have been further developed, and the earthing device has been formally approved and sealed by the Board of Trade. There is a considerable demand for the D.P. battery, both from the trade and private users.

J. K. FAHIE AND SON, of Dublin, have been fairly busy during the year, especially in the capacity of consulting electrical engineers. Numerous inspections of suitable water power in the country districts for driving dynamos have been made, and various reports prepared. The firm have now under their superintendence several installations, the most important carried out during the year being that of the suburban residence of the well-known Southern brewer, J. J. Murphy, Esq., J.P., on the banks of the Lee. The firm expect to have a good share of electrical work on hand during the present year.

CROMPTON-HOWELL ELECTRICAL STORAGE CO.—We give the contribution of this company to the year's information *re* work done in their own words: "As so much has been said about the inevitable losses which the use of accumulator storage entails on an electric supply system, we think this is a fitting opportunity to enclose the annual report we have just received from the engineer of the Kensington and Knightsbridge Company, which has been our oldest customer, and has continuously used our accumulators for nearly seven years. We give you the figures exactly as received, although they show a low efficiency during last January and February, due to the fact that owing to the exceptionally severe weather the temperature was so low that they were working in an exceptionally unfavourable manner. As soon as means were provided for maintaining the battery-rooms at a regular temperature, the efficiency at once rose to the average of the year—viz., about 79 per cent. These efficiencies are the actual commercial efficiencies taken at the recording meters. The losses include not only the losses in the batteries themselves, but those due to the resistance of the charging leads, which connect the distant accumulator station with the generating station. The losses shown, therefore, are accurately representative of the total losses due to the use of accumulators for that part of the output which passes through them.

WORK DONE BY ACCUMULATORS IN 1891.

	KENSINGTON COURT AND QUEEN'S GATE BATTERIES.				KENSINGTON COURT ONLY.			
Month, 1891.	Charge in ampere-hours.	Discharge in ampere-hours.	Efficiency, ampere-hours.	Efficiency, watts.	Charge in ampere-hours.	Discharge in ampere-hours.	Per cent. ampere-hours.	Per cent. watts.
January	113·174	77·592	68 6	66	—	—	—	—
February	96·603	74·005	76·6	69	45·742	41·277	90	83
March	82·977	73·230	88·3	78·5	—	—	—	—
April	101·021	90·487	89·1	79	46·868	43·142	92	85·5
May	89·257	82 274	92	80	43·311	40·525	93·5	86·5
June	95·603	88·028	92	80·5	—	—	—	—
July	99·778	91·864	92·2	86	39·015	26·549	93·6	86·5
August	78·856	71·283	90·5	84	—	—	—	—
September	75·274	68·416	91	84	33·873	31·265	92·5	85·5
October	91·814	83·919	91·4	80·5	46·349	42·350	91·5	85
November	104·114	96·987	93	86				
December	115·555	104·052	90·5	81·5				
Totals	1,144·036	1,002·137	88	79·5				

REMARKS.—During January no provision had been made at the Queen's Gate battery station for heating so that the efficiency fell very low. During March improvements were made in the system of charging the batteries, hence the increased efficiency. The efficiency in watts cannot be calculated directly from the figures given for ampere-hours, as the results depend upon the proportion of work done by the batteries at each station. Owing to the fall of potential in the charging mains to Queen's Gate, the watt efficiency at that station must be lower than at Kensington Court; also it depends on the amount of charging done separately or in connection with the lighting. A few readings are given showing the efficiency of the Kensington Court home battery taken by themselves, in order to show how considerably the loss in the charging mains reduces the total average efficiency for the year.

This at Kensington is one-eighth part of the whole output, so that the use of accumulators in this station during the past year has only entailed the loss of 2½ per cent. in the entire output. Mr. Miller's remarks are interesting in showing that the efficiency obtained from the home batteries, which does not include losses in charging mains, is practically in excess of 85 per cent."

CRYSTAL PALACE DISTRICT ELECTRIC SUPPLY COMPANY.—The business of this company has been entirely reorganised during the last year. The principal works with which the company was connected were the provisional orders for the Crystal Palace and district, and for the city of Oxford; also the small central station in Walbrook. All business, except that connected with the Crystal Palace and district, was transferred, the name of the company having been altered to that of the Crystal Palace District Electric Supply Company, Limited, carrying on solely the business under

the provisional order for that locality. The provisional order for Oxford is being carried out by a local company entitled the Oxford Electric Company, Limited, who have contracted with the Electric Construction Corporation for a complete plant comprising central station for the supply of a continuous current of moderate high tension, with subsidiary transformer and accumulator stations, and an application is now before the Board of Trade for the transfer of the provisional order to the local company in question. The Walbrook station has been transferred to the Electric Construction Corporation. The generating station at Sydenham is ready for the supply of current to the exhibitors at the Crystal Palace. The works have been carried out with extraordinary energy by Messrs. J. E. H. Gordon and Co., whose contract was signed on the 13th August last, and the works are now practically completed, as already described in this journal. A large number of the exhibitors at the Crystal Palace have contracted with the company for the supply of current, including, among others, the following: Edison-Swan United, Wm. S. Freeman, Shirley and Co., James Pitkin, the Mining and General Electric Lamp Company, Woodhouse and Rawson United, the Medical Battery Company, the Electric Construction Corporation, Consolidated Telephone Constiuction, and Maintenance Company, Thomas Jenner, Rashleigh Phipps and Dawson, the Fowler-Waring Cables Company, Swinburne and Co., Frank Suter and Co., Marryat, Lillywhite, and Co., the Electrical Power Storage Company, the Telegraph Manufacturing Company, Evered and Co., Anders Elliott and Chetham-Strode, the Western Electric Company, etc. At Oxford the building of the generating station at Cannon Wharf, on the banks of the River Thames, and which will occupy 100ft. frontage to the river, is being rapidly pushed forward, and it is expected that the supply of electricity will be ready early in the spring. The demand in Oxford promises to be very large, as the project has been very favourably received by the heads of colleges and public institutions, the Corporation, private residents, traders, etc.

The General Electric Company can again report considerable expansion in their works at Manchester during the year 1891. They have taken three more buildings, and increased the number of hands from about 400 to nearly 600. The demand for electric light fittings, such as switchboards, switches, cut-outs, ceiling roses, lampholders, has been very large, and at the beginning of the winter stocks were thoroughly exhausted, and the company had to make great efforts to cope with the demand. They have largely increased the factory for making meters, both current and volt or ammeters, and the facilities for calibrating and testing are now such that they can fill any orders at early dates. It was natural that the department for electric signalling should be increased considerably during the last year, as then the telephone patents expired, and immediately after the expiry the company was extremely busy and full with orders for transmitters, receivers, and all kinds of switches. The Johnson microphone, of which they are the sole makers, has especially taken extremely quickly, and has found its way already into several large and important central stations. As for the general supply business, the home trade has been increasing very considerably during the year, both in London and most of the country towns, but it is unfortunately found that the prices are being cut down in all articles, leaving a margin of profit which seems ridiculous, considering the newness and risks of the electrical trade, which leaves only one consolation—that it is impossible to continue. The trade to the Continent and to the Colonies, however, has not only increased in volume, but has also been more profitable, and the company finds that some of the most outlandish and uncivilised countries are becoming their best customers. The endeavour for the new year is to again improve all china fittings to a degree of perfection to which they have never attained, and to keep large stocks in advance so that contractors may draw from stocks in future without the expense and risk of keeping stock for themselves.

General Electric Power and Traction Company.—The close of 1891 sees the end of the first financial year of this company. It will be gathered from the directors' report, which was published on the 18th of December, that electric traction has been almost entirely stopped by legislative and local obstacles of so stringent a character as to practically prohibit business; in spite of this, however, considerable progress has been made. The service of electric cars at Barking has been improved, and advantage has been taken of the experience there gained in estimating for maintenance contracts on a large and commercial scale. Indeed, as was foreshadowed by the chairman's speech to the shareholders, the company have reason to expect traction orders to the extent of £150,000 during the coming year. With the knowledge they have gained there is but little doubt of a satisfactory result. The sub-contract with the E.P.S. Company for the maintenance of the accumulators at a fixed mileage rate removes the only doubt which capitalists may have had for the success of this form of electric traction, for it is needless to say that the combined companies, with their unrivalled opportunities of gaining experience, are quite capable of carrying out contracts entrusted to them. Apart from Barking, considerable progress has been made in other places. For some months a self-contained car was run over the tramway system at Liverpool, carrying ordinary loads and keeping schedule time, thus proving the practicability of this class of car over steep grades. A smaller accumulator car is now being built for use on the Birmingham lines, so as to make comparison with the cost of the larger double-bogie trams running there at present. It is firmly believed by the company that these small accumulator cars, carrying about 36 passengers, will satisfactorily solve the problem of tramcar propulsion in our crowded thoroughfares. In mining work the company has been very busy, and has fully doubled the quantity of work done in this department in the preceding year. Electricity has been used for lighting, pumping, hauling, fan driving, and coal-getting with unvarying success. In launch work the company stands practically alone, and during the busy periods of last season controlled the pleasure traffic of the Thames. During week-ends the whole of their available boats were usually let, and in some cases could have been let two or three times over. In spite of the bad season this department has been a distinct success, and should the weather be at all favourable next year a very handsome dividend may be evidently looked forward to from this department. Viewing the rapid extension of launch work, the company have acquired land near Chertsey, and are now building hulls for their clients and for future extensions of the Thames fleet. During the Naval Exhibition a special feature was made of this branch of the company's business, and an electric pinnace of the man-of-war type was shown equipped ready

for slinging in davits. This led to some important business with foreign Governments, and three sea-going boats, 50ft. in length, were dispatched to Russia. On Lake Windermere the company's launches were usefully employed during the whole of the season, and derived their power for charging solely from a turbine, the first instance of the kind known when water power was used for charging boat accumulators. Arrangements have been concluded with the Manchester Ship Canal Syndicate by which a fleet of electric launches will run on part of the Ship Canal early in the spring. The company are about to erect an extensive electric copper-refining plant on the bank of the Thames, which they hope to have in full operation about April next. The company have given considerable attention to electric lighting both in London and the provinces, and have had a very satisfactory amount of work for this department. The sale of dynamos and motors for general purposes has largely increased, and the company are confidently looking forward to a further extension of the motor trade, with both direct and alternating current, as the use of electricity from central stations becomes more largely adopted.

Ernest Scott and Mountain, Close Works, Newcastle-on-Tyne, have been extremely busy during the whole of the past year in their electrical department, which has very largely developed since the firm commenced the manufacture of electrical machinery and the supplying of electric light installations. During the year the firm have supplied for their various installations and to trade customers at home and abroad over 150 dynamos of various sizes, most of them being of large size, and amongst the important installations which they have supplied are the following: The large flour mills at Dunston-on-Tyne, which have recently been erected by the Co-operative Wholesale Society, have been lighted throughout by electricity, the installation consisting of two Tyne compound-wound dynamos, each capable of running as a maximum 600 16-c.p. lamps, one Tyne compound-wound dynamo capable of running 15 2,000-c.p. arc lamps, and one Tyne compound-wound dynamo for the pilot installation capable of running 100 16-c.p. lamps. Throughout the mill there are installed about 600 16-c.p. lamps, this being the largest electric light installation in any flour mill in the United Kingdom. Since the starting of the installation in February the plant has run without the slightest hitch of any kind, and has given great satisfaction to the society. Messrs. Arthur and Co.'s factory, at Anderston, Glasgow, has also been lighted by the same firm, this installation consisting of two Tyne compound-wound dynamos capable of running 600 16-c.p. lamps each, and 700 lamps and fittings fixed throughout their new works. Messrs. Jones Bros. and Co.'s mills at Leigh and Bedford, near Manchester, have also been lighted. This installation consists of two 600-light Tyne compound-wound dynamos and 800 16-c.p. lamps. The firm have lighted several frozen meat stores in England and abroad; amongst these may be mentioned Messrs. J. Nelson and Sons' stores at Bristol, the Northern Counties Ice Company's stores, Newcastle-on-Tyne, and a large cold meat store in Brazil. Amongst smaller installations that the firm have carried out is the lighting of Messrs. H. S. Edwards and Sons' dry docks at North Shields; this installation was specially designed to suit the firm's requirements, and has been arranged so that petroleum oil steamers can be repaired by means of the light, the lamps being lowered into the holds by means of flexible cables strongly armoured. For Messrs. Edwards's Shipbuilding Company several electric light installations have been supplied for steamers, all of these having given great satisfaction. An installation has also just been completed for the Armagh Spinning Company, Armagh, Ireland, this installation consisting of one 400-light dynamo and 400 lamps and fittings, and has given the Armagh Company every satisfaction; in fact, they are anticipating a considerable extension amongst their other mills. Amongst other work in hand, the firm advise us that they are lighting the Fustian Machine Cutting Company's mills in Manchester, this company having been formed to cut velvet by machinery, instead of by hand as previously. The electric light installation will consist of two 40-unit dynamos, each capable of running 650 16-c.p. lamps, and a pilot dynamo to run 100 16-c.p. lamps, about 1,000 incandescent lamps and fittings being installed throughout the mill. Lord Ellesmere has also placed his contract with the firm for the lighting of a large private house and training establishment he is building at Newmarket. A large installation for Mr. Walter Jones, Cheshire, for the lighting of his private house is just upon completion, and a large installation for the Bolton Technical School will be completed early next year. The contract was placed with Messrs. Ernest Scott and Mountain, Limited, for the technical school chiefly on account of the great success of their installation at the *Bolton Evening News* Printing Works, the latter installation having been completed early in the year. The firm inform us that they have supplied a large number of dynamos and complete installations for South Africa, where they have an established office, and they anticipate doing a large business in the future with this country as things improve. The firm inform us that they are now bringing out several new designs of electrical pumping and mining plant for which there will undoubtedly be a very large demand in this district, and they expect to settle several important contracts for this description of machinery. Amongst private local installations completed during the past year may be mentioned the lighting of the Union Club, and, amongst others, the private houses of Messrs. B. J. Sutherland, R. H. Haggie, W. Sharp, C. D. Hill, J. Cameron Swan, C. M. Forster, R. B. Duncan. Installations have also been completed for G. and J. Stubley, Batley; S. Knowles and Co., Bury; Henderson and Co., Durham; Paterson, Elder, and Co.; and Crann and Co., Leith; Scott and Co., Greenock; Broadbent and Sons, Shires and Co., Slaithwaite Spinning Company, Wood, Sons, and North, Vickerman and Co., Rayner and Co., Huddersfield; Amos and Smith, Hull; Hutchinson and Co., Kirkcaldy; Hennochsberg and Ellis, Liverpool; Manchester Ship Canal, Baxendale and Co., Manchester; Rossendale and Co., Rawtenstall; Fairbrother and Co., Sheffield; A. and J. Macnab, Edinburgh; River Wear Commissioners, Sunderland; Arnold, Perrett, and Co., Gloucester; and the Argentine Meat Company, Brazil.

Newton Electrical Engineering Works.—This firm commenced business in 1890. The business has increased very rapidly, and as the firm lays itself out to work for the trade, the rapid increase has necessitated the building of much larger works. During the past year orders for automatic switches and transformers have come freely to hand. An order has just been received for a high-pressure continuous-current plant, consisting of generator and transformer, to go to Italy. Among other work, installations of lighting plant have been

executed for Major R. G. Godson, Westwood Park, Droitwich; Rev. G. E. Hermon, Doublebois House, Doublebois, Cornwall; and in the factories of Messrs. Candy and Co., Heathfield; Mr. J. A. Sherrin, Weymouth; and Messrs. Simpson, Strickland, and Co., Dartmouth. Mr. Newton was, if we remember rightly, an exhibitor at the Bath and West of England Show, and is one at the Crystal Palace Exhibition.

RANSOMES, SIMS, AND JEFFERIES.—During the past year Messrs. Ransomes, Sims, and Jefferies, Limited, of Ipswich, have been very busy in supplying motors for electric light plants, many of which have been for installations in Great Britain, France, Spain, Germany, etc., as also for Australia, India, and the East.

JOINT-STOCK COMPANIES WOUND UP IN 1891.—The following is a list of electrical companies which were wound up during last year:

VOLUNTARILY WOUND UP.

Jan. 1.—Woodhouse and Rawson Electric Manufacturing Company.
Feb. 13.—Cadogan Electric Light Company.
Mar. 16.—The South of England Telephone Company.
Mar. 20. -Woodhouse and Rawson Electric Supply Company of Great Britain.
April 17.—Electro-Metallurgical Company.
April 22.—Simplex Electrical Syndicate.
April 23.—Electrical Engineering Corporation.
July 3.—Corinthian Electro-Medical Battery Company.
Sept. 15.—Institute of Medical Electricity.
Sept. 30.—City of London Electric Lighting (Pioneer) Company.

The winding up of the Cadogan Electric Light Company, begun voluntarily, was ordered to be continued under the supervision of the Court.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE TAXATION OF MACHINERY.

SIR,—My committee, in conjunction with a large number of public and representative bodies, have arranged to hold a conference to consider the terms of the Bill proposed to be introduced into the House of Commons in the ensuing session to declare the law as to this question, and the Council of the Manchester Chamber of Commerce have kindly granted the use of their board-room on the 26th January for the purpose.

If those of your readers who desire the success of this Bill will communicate with me, I will forward them a draft of the proposed Bill and any further information required.

The attendance is particularly desired of delegates from the associations representing the various interests of users of machinery.—Yours, etc.,

G. HUMPHREYS DAVIES, Secretary.

National Society for the Exemption of Machinery from Rating, 8, Laurence Pountney-hill, E. C., Jan. 5, 1892.

NOTE ON INTERFERENCE WITH ALTERNATING CURRENTS.

SIR,—In the abstract of my paper before the Physical Society on the 18th ult., printed in your last number, there is an error I should like to correct.

It is stated with regard to the experiment described—on the 100-kilowatt alternator, three-quarter mile of concentric cable, and 18-kilowatt transformer—that switching on the concentric cable produced the same rise of pressure at the alternator terminals whether the transformer at the far end of the cable was loaded or not. The facts of the case are as follows: The same rise of pressure was observed at the alternator terminals on switching on the cable, whether the transformer at the far end was connected to the cable or not, when the transformer secondary was open or loaded only with about a dozen 60-watt lamps (a very small load for an 18-kilowatt transformer).—Yours, etc.,

HAMILTON KILGOUR.

January 7th, 1892.

ELECTRIC LIGHT DECORATIVE FITTINGS.

BY SYDNEY F. WALKER.

Mrs. J. E. H. Gordon has done good service by her article in the *Fortnightly Review* a short time since dealing with this subject.

Decoration is essentially the province of the artist, and every lady is, or should be, an artist in her own home. Now, too, that it may fairly be claimed that electric house lighting has come to stay, and that town after town is laying down plant, tearing up its streets, and preparing a hearty welcome for the new illuminant, surely it is time that a new departure was made in the matter of the decorations which form part of the fittings that carry the lights, whatever they may be. Has not the time arrived when the electrical engineer and the artist should collaborate, to produce something different from the stiff gas pendants and brackets that have pained our eyes for so long?

Of course there is still a good deal to be said for the old forms of fittings, with their more or less concealed pipes, and their ugly burners. As long as gas was the illuminant, and gas-pipes were necessary, they must be worked into the fittings of gas brackets and pendants. You might have flying Cupids, or Grecian statuary, but you must have a pipe concealed inside them, and the pipe must be visible, in some form or other, where the outlet for the gas was placed. Usually, too, the gas flame required shading, and the globe that was used for the purpose must be supported in some way.

As the gas burnt best, or at least gave the best light, when escaping upwards, nearly all gas-fittings were so arranged that the burners provided for the egress of the gas, were pointing in a vertical direction.

The early types of electroliers naturally took the form of gas chandeliers and gas brackets, but with the burners turned downwards. Now the question arises, can all this be changed? It is no longer necessary that the burner shall point in any particular direction. The burner itself is light, and therefore does not require the massive apparatus for its support that are often found in use with large gas chandeliers. Can the pipes be dispensed with, or is it wise to retain them in all their hideousness as a protection for the wires that are passed through them?

It is certainly convenient to conceal the wires inside the tubes of a chandelier, or electrolier, if the term be preferred; but it would be better to have no pipes and no chandeliers at all. Every time you thread a covered wire through a pipe, especially when it is curved, as most of them are, you run a great risk of damaging the insulation of your wire; and it therefore becomes necessary to pay for an increased cost of the wire to provide for this possibility, as well as to pay for the expensive electrolier which you no longer require. Flexible cords, well insulated in the process of manufacture, run less risk of damage to their insulation, and of consequent short circuits, when hanging freely in air than when confined in a tube.

If this is correct, then the whole of our electric lighting arrangements require remodelling.

But there is another point in which domestic lighting by means of electricity differs very much from that by means of gas. With the latter, except for street lighting, only one power could be obtained from any single burner, unless special arrangements were made, so that increased light was always obtained by grouping a number of these burners together in one chandelier, which was generally placed in the centre of the room. Of late years, under the pressure of the probable competition of the new illuminant, something has been done in the matter of distributing gas burners round the walls of the room to be lighted; but even now, in large halls, illumination is usually by means of a huge cluster of burners near the centre, supported by a few smaller clusters in other parts. The brackets placed round the rooms of private houses, too, perhaps do not appear very ugly to us, because we are accustomed to them,

but viewed with other decorations they are certainly not picturesque.

With electricity, we are under no obligation to multiply our lamps. If we require the light of more than one in any particular place, we may have the light given by two lamps, or a hundred if we wish, concentrated in one lamp, requiring only one set of fittings. Or we may have the light distributed about the room, on its walls, or suspended from the ceiling at various points, without the necessity of destroying any artistic effect that may have been designed.

Should not, therefore, a new line be struck out in this matter, gradually absorbing the full adaptability of the electric light to its surroundings? Gas-burners are in the room, but they and their supports are rarely of the room—they are excrescences. May not electric lamps be arranged to be of the room, to form part of its decorations, whether the room be devoted to eating, to lounging, or to gossip? But there is another point that should be noticed, and that is, placing the lamps where they can be of most service. With gas this is often a difficult matter, owing to the necessity of providing for the harmless combustion of the illuminant. With electricity this necessity does not exist.

Mrs. Gordon gives a useful hint, amongst others, that the lamp should not be placed so that it is reflected in a mirror right into the eyes of whoever may be in front of it. With gas it has often been very difficult to avoid this; in fact, candles by the side of a dressing-table or cheval-glass are almost a necessity where gas is employed. With the electric light it should be a simple matter to accomplish the usually awkward operation of viewing one's back hair—a point that most men will not trouble about, and that designers of electric light fittings may be excused if they do not fully appreciate, but which is of great importance to ladies. Then what form shall the new style of decorations take? Already something has been done in the right direction. Lamps are shaded by leaves moulded in thin metal of various hues, and are made to peep out of shells and so on. But here again, the lamps are in the leaves but not of them. The leaves are in the room but not of the room. Leaves that could spring from no living tree, and that appear to grow out of a brass tube, or from nothing, are hardly artistic in the real sense of the term. Why should not the lining, shall it be called, of a lady's boudoir be composed of the spreading branches of a tree, and the lamps either be the fruit of the tree in shape and colour, or be concealed by its leaves? How deliciously cool and soft to the eyes such an arrangement would be. English plants offer numbers of subjects which, properly worked up, would lend themselves to this idea; and in tropical plants would be found more than every artist of every nation could possibly utilise for centuries.

But the artist is by no means confined to the vegetable world for subjects that will help him in this matter. The animal world, in its various forms, offers an abundance. What could be prettier, for instance, for a staircase light than a kitten seated on the lower balustrade playing with a ball, the ball being the lamp and the kitten one of those wonderful creations in china that are to be seen in the potteries. Classical and historical subjects also would lend themselves very readily to the same object. For a corner light, for instance, or for some nook in a cosy drawing-room, such a group as that of Eve and the serpent, with our common mother in the act of plucking the forbidden fruit, the fruit, of course, being the lamp, would be far chaster than anything to be seen in any drawing-room at the present day. Remembering, too, that the lamp may take any form, it being merely a question of manufacture to arrange the details, such a group as the death of Cæsar at the hand of Brutus, the lamp in this case being the dagger; the death of Harold at the Battle of Hastings, the lamp being the arrow, and numerous others, would well adorn a library or a study. Flying Cupids would come in well in certain cases, but they should be of china, and should either form the lamps themselves, or be semi-transparent shades for the lamps.

Doubtless the whole of the above sounds revolutionary, but surely electricity is nothing if not revolutionary. It is the mission of the youngest of the sciences to ease the lot of mankind, and to beautify the world, and every home in the world.

NEW SOUTH WALES ELECTRICAL CLUB.

INAUGURAL ADDRESS.

A meeting of the above society was held at the rooms of the Engineering Association of New South Wales on Thursday evening, the 12th November, 1891. After the usual preliminary business, the president, Mr. E. C. Cracknell, delivered his inaugural address as follows:

As I have no doubt nearly all of you have read the early history and progress of magnetism and electricity, I propose only to deal with the early discoveries, the inventions, which were the outcome of these discoveries, and the developments which have resulted from both, for the comfort and enjoyment of the present generation. Little did the early *savants* know what their energy and zeal in the cause of science, when they were toiling with their slender means and more slender resources, would bring about for the benefit of mankind. The names of these illustrious pioneers I shall allude to from time to time during this address, and I am sure you will endorse every sentiment as well-merited praise for their exertion and, in most instances, poorly-requited labours. You will find that the world is indebted to the Chinese not only for the discovery, but for utilising the magnet. It is stated in Chinese history that 2,637 years B.C. Hoang-ti constructed a chariot upon which stood a prominent female figure which indicated the four cardinal points, which always turned to the south, no matter the direction taken by the chariot, by which means he succeeded in capturing the rebellious Prince Techi-yeou, the Emperor's troops who were pursuing the Prince having lost their way through heavy fogs on the plains of Tchou-tou, in Tartary. This, no doubt, was the first discovery of the magnetic needle, or mariner's compass. The Greeks also took credit that 1,000 years B.C. a Greek shepherd observed the attractive power of the loadstone at Magnesia, in Lydia, his metallic crook having been attracted by a rock now known as native loadstone. Shakespeare says in "Midsummer Night's Dream," "You draw me, you hard-hearted adamant, and yet you draw not iron, for my head is true as steel." Agamemnon, B.C. 1084, employed a line of optical signals to advise his Queen of the fall of Troy. So far I have merely alluded to the discovery of magnetism in the early days and its application by the ancients, but I must now refer to the first observation made by Thales, of Miletus, that electricity was very strongly developed by friction in amber, which very soon after astonished the Romans as well as the Greeks by its attractive power over light bodies, such as paper, straw, and leaves, in the same way as the magnet attracts iron. As lightning existed long before any of the dates mentioned, it would not be fair to exclude such a powerful and subtle agent from a passing remark. It has been stated that the Temple of Jerusalem was never struck by lightning during a thousand years, for the simple reason that a forest of golden points covered its roof, and that the roof was connected with the caverns in an adjacent hill, in consequence of which the points would act as conductors. This might be a new idea for Prof. Oliver Lodge, who would find that his bird-cage protection to buildings from lightning was as old as Moses, who was born 1,570 years B.C. A passing allusion to ancient medical treatment in a primitive way by electricity may not be out of place. In the year A.D. 20 it is recorded that a freedman of Tiberius was cured of gout by shocks received from the electric eel, and Fahie states that along the banks of the Calabar River, in Africa, the natives employed the electrical properties of the gymnotus for the cure of their sick children. Yet it is within the recollection of most of us that the whole medical profession, backed up by their leading journals, scouted electricity as a curative agent, as quackery amounting to fraud. How very different are their opinions at the present day, since there is no medical man amongst us who would dare to tell his patients that he does not believe in electricity as a curative agent? But to continue these early discoveries. Gore tells us that the Romans, A.D. 410, were acquainted with electric separation of metals—that is, that metals acquire a coat of copper on being immersed in a copper solution. That most interesting little experiment known to us as "De la Rive's battery" appears to date back as far as A.D. 425, the only difference being that a magnetic needle was attached to a piece of cork floating in a vessel of water, which Bishop Severus found would direct its polarity by placing a magnet under a thick wooden table upon which the vessel was placed. As late as 1260 Brunetto Latini speaks of the mariner's compass as likely to be useful at sea; but he adds, "No master mariner dares to use it, lest he should fall under the supposition that he is a magician, nor would sailors venture to sea under his command if he carried with him such an instrument." It was not until 1269 that the variation, or the declination, of the compass was understood. Marco Polo was evidently aware of the compass, as during his voyage of discovery when he set out from Acre, in 1271, and returned to Venice, in 1295, he was provided with and understood the use of the magnetic needle, as on his journey South he left the North Star out of sight, which in

northern latitudes was previous to this time considered the mariners' guiding star. We have been for many years under the impression that Oersted was the first to give us the foundation for the needle telegraph, but Mr. Mottelay, in his "Chronological History of Electricity, Galvanism, Magnetism, etc.," has turned up from the "Encyclopædia Britannica," under an article on "Optics," by Prof. Stanley Jevons, that as far back as A.D. 426 in "Speculum Lapadium" there is the following allusion: "I do not fear; with a long-absent friend, even though he be confined in prison walls, we can communicate what we wish by means of two compass needles circumscribed with an alphabet." In the reign of Queen Elizabeth it appears that our own countryman, Dr. Gilberte, of Colchester, physician to the Queen, published a great work for that date, in which he enumerates all the substances which are susceptible to electrical excitation, and makes use of the words electric force, electric connection, and electric attraction. Now we make a jump of about 60 years, and find that Otto Van Guericke, of Magdeburg, was the first to construct a practical electrical machine, consisting of a globe of sulphur cast in a glass sphere, which, when excited by its being revolved against a rubber, emitted both sound and light. In 1720, to Stephen Grey, a pensioner in the Charterhouse, is attributed the first discovery of the principles of electric conduction, and its insulation, as well as to the fact, but not to the principle, of induction. Thus to Grey is due the credit of having laid the foundation of electricity as a science. In 1729, Grey and Wheeler succeeded in transmitting electricity through packthread, supported by silken cords, a distance of 765ft., and through wires a distance of 886ft. To Dufoy, in 1733, is due the discovery of two kinds of electricity—viz., known as the phenomenon of attraction and repulsion. Dufoy says there are two kinds of electricity very different from one another—vitreous or positive, and the other resinous or negative. The first is that of glass, rock, precious stones, etc., and the other that of amber, copal, gum lac, silk, thread, paper, and other substances; thus those which are vitreous repel all those that are vitreous, and attract all those that are resinous. Dufoy also observed that by repeating Grey's experiment, by wetting the packthread he was enabled to convey a current through 1,256ft. instead of 675ft. when dry. In 1746, the discovery of the Leyden jar was made. But it appears rather doubtful whether, from an experiment made a year earlier at Dantzic, that the latter place should not be credited with the invention; but Sir William Watson, the English scientist, is entitled to the credit of the double coating of the jar, as well as the plus and minus of electricity. In the same year the first glass-plate and cylinder machines were constructed. The next work in the early history of electricity was Franklin's famous kite experiment, in 1752, in which he proved that the lightning's flash was identical with the spark from a Leyden jar. Galvani's classical experiment with the frog's leg, in 1786, closely followed, in 1800, by Volta's publication at the Royal Institution of his discovery of the voltaic battery, formed on a basis on which was founded Oersted's important discovery, in 1819, of the effect produced on a suspended magnet by an adjacent current wire. Ampère's theory of electric dynamics, Schweigger's invention of the galvanometer, and Seebeck's discovery of thermo-electric currents, 1822; Ohm's law, laid down, in 1827, and Arago's publication of his researches on the rotary effect of adjacent current-carrying conductors, culminated in the magnificent researches and improvements of Humphry Davy, and that truly great man Michael Faraday, who in 1832 discovered the principle of electromagnetic induction, and who has laid down for us the law of electrostatics, induction, electrolysis, and diamagnetism, and whose book on "Experimental Research" is still a mine of wealth for the inventor, and is only equalled in value by the works of James Clerk Maxwell, of the value of which we are comparatively still ignorant, and in which many a clever man has found his own discoveries clearly laid down, and worked out mathematically many years previously by this wonderful man. From this era electrical history may be said to have ended and electrical science to have commenced, and I propose now to go more deeply into the development of these branches of the latter which are now in ordinary commercial and domestic use. I will now ask you to follow me in a rapid glance at the development of electricity as applied to telegraphy. In Holy Writ we have a prophetic allusion to the telegraph in the thirty-eighth chapter of Job, "Canst thou send lightnings that they may go and say unto thee 'Here we are.'" In the family the electric telegraph has become a "household word," bringing absent members into sympathetic contact of heart and mind in the same instant of time. Of commerce it has become the very life-blood; it has gathered the civilised world together into instant and direct intercourse; a network of sympathetic intelligence encircles the earth, and we feel it difficult to imagine it had not always existed. Imagine it removed! There is an ebb of centuries in the life of civilisation, and yet it is but little more than 50 years since the first practical telegraph commenced to work. The names of those who have from time to time essayed to solve the problem of conveying information by means of electricity are almost legion. Philosophers from very early days had tried, and some met with a certain measure of success. Amongst others in 1786, Sir William Watson passed electricity through 9,000ft. of earth and water across the Thames, and through 18,000ft. of wire suspended upon poles, at Shooter's Hill. In the following year Franklin repeated like experiments at Philadelphia. In 1774, Lesage, at Geneva, reduced to practice a plan of telegraphing by static electricity and pith balls, using 24 wires, one for each letter of the alphabet. Lomond, in 1786, combined the signals of the pith balls so as to diminish the number of wires, and in 1794 Betancourt worked a pith-ball telegraph from Madrid to Aranjuez. In the same year Reusser proposed to make the elecric spark illuminate a letter formed of separate pieces of tinfoil placed in the path of the discharge, using a separate wire for each letter. We are now come to the present century, when, in 1816, Ronalds worked his system of pith balls and dials through eight miles of wire at Hammersmith. This was the first and last successful application of static electricity to a telegraph. In 1830 Schelling invented his telegraph with five needles, which up to that time was the most perfect plan of a telegraph yet produced, and in 1835 he reduced it to a single-needle arrangement, and exhibited the system at Bonn. The history of the subject so far shows us that no single individual can lay claim to the distinction of being the inventor of the electric telegraph; 1837 is the year of the first practical electric telegraph, and it remained for Cooke and Wheatstone in that year to first demonstrate the practicability of telegraphy being worked on a commercial basis. It was once a popular fallacy in England and elsewhere, that Cooke and Wheatstone were the original inventors of the electric telegraph. It will be seen, however, that the telegraph grew up little by little, each inventor adding his little to advance it towards perfection. Messrs. Cooke and Wheatstone were the first to establish a telegraph for practical purposes on a comparatively large scale, and in which the public were more nearly concerned than in those experiments in which the ends of wires were brought into laboratories and observatories. Morse and Steinheil have also been thought by many to be the fathers of the telegraph, but whilst in 1837 a line had been built and was in working order between London and Slough, it was not until 1844 that the first wire was built from Washington to Baltimore, and a message, dictated by a Miss Ebsworth—which is still preserved in the Hartford Museum—announced the existence of a practical telegraph on the American continent. Wheatstone's first instruments had five needles, and as many lines were required between each station to work the system. It was, however, rapidly improved upon, and the number of needles reduced to two and then to one. A return wire was, however, required to complete the circuit. It is to Steinheil that we are indebted for the discovery that the earth could be utilised for the return circuit, a discovery which was of the greatest service in further developing telegraphy. Bain, the inventor of the chemical telegraph, also independently discovered the principle somewhat later. From this time the strides made in the science were marvellous. In America, England, and the whole of Europe, inventors were busy at work, and almost every year saw improvements and new systems brought into use. To enumerate the different systems would comprise an extensive catalogue, and it would take up too much of our time to trace the electric telegraph through its many subsequent stages of development. Printing, automatic, chemical, harmonic, sound, and visual telegraphs followed each other in bewildering confusion, each and all equally well adapted for the special purpose for which they were designed. Indeed, perhaps in no other invention of modern times have so many different methods been devised to obtain the same result, the amount of ingenuity displayed by the different inventors of the many systems of telegraphs, together with the manner in which well-known scientific laws have been brought to bear in their construction, will render the electric telegraph one of the greatest monuments of the inventive genius of the present century. Like most other branches of electrical science, telegraphy even now can hardly be considered to be much more than in its infancy. When it is remembered that a little more than 50 years ago telegraphy was merely a scientific toy requiring many wires to transmit a single word, that the use of the earth as a return circuit was not made use of practically, it will be seen what strides have been made when one wire is now made to do the work of two, four, six, and even more; and when so much has been done in so comparatively short a time, one begins to think it quite within the bounds of possibility that the day will yet come when no wire at all will be required, but the earth itself will be made the means of communication from one end of the world to the other. The first line of telegraph in Australia was established in Victoria between Melbourne and Williamstown in the year 1854; in South Australia, between Adelaide and Port Adelaide and the Semaphore in the early part of 1856; in New South Wales, between Sydney and Liverpool, and Sydney and South Head in January, 1858. The first line opened for intercolonial traffic between Sydney and Melbourne was in November, 1858; these were speedily followed by lines Sydney

to Bathurst and Sydney to Newcastle; other lines soon became necessary, and now we have in this colony alone no less than 23,500 miles of line in actual work. (The progress made in the four principal colonies from 1860 to 1890 was demonstrated at this stage by a tabulated statement, which showed the length of line in use in each succeeding decade, the number of messages transmitted, and the revenue received. Some details of the amount of telegraphic business transacted in the United Kingdom, France, and New South Wales were also given in a form which admitted of ready comparison). I cannot pass from this portion of my subject without referring especially to the wonders of submarine telegraphy, and of the signal services rendered to that particular branch by both Wheatstone and Sir William Thomson. The greatest achievement of the electric telegraph is unquestionably the instantaneous transmission of intelligence across seas. The first cable of any length was laid in 1850 between Dover and Calais, but it only lasted one hour before breaking down. Several small cables were laid during the next few years with more or less success, until on August 5, 1858, the first Atlantic cable was successfully laid, and congratulatory messages were for the first time flashed from the Old to the New World. This cable was faulty when laid, and gradually got worse, till three weeks after its submersion it completely broke down. Sufficient success had, however, been achieved to warrant commercial men taking the matter up, and when this is the case the ultimate success of the undertaking may, I think, be generally looked upon as moderately secure, for these gentlemen usually require pretty good reasons before they "plank the dollar down," as our American friends would say. Several Atlantic cables followed, each showing a marked improvement both in electrical and mechanical construction, till at the present day 11 cables connect the American continent with Europe and England, and there is hardly a corner of the globe which is not in direct communication with the great centres of population. The earlier instruments used for the working of the cables, as you are no doubt aware, consisted of Thomson's reflecting galvanometer, the movement of the beam of light to the right or left of zero indicating the dot and dash of the Morse code; but very soon Sir William Thomson brought out his syphon recorder, by which means the signals were recorded on an endless tape in Morse characters. This instrument is alone a monument to its inventor and a marvel of ingenuity. But great as have been the wonders wrought by the telegraph, it remained for Bell to astound the world by announcing the advent of the telephone, for there is no doubt that to Bell must be credited the honour of first devising a telephone fitted for practical use. As far back as 1667 we find sound was transmitted to a distance by the aid of a wire or tight-drawn string, but it was not till 1877 that electrical reproduction of speeches was rendered practicable. Page's discovery of the emission of sounds by an electromagnet when subject to a rapid succession of currents, which was termed the "magnetic tick," led to further experimenting on the part of Boursel, De la Rive, and others, till in 1861 Philip Reis, of Fredrichsdorf, invented an apparatus which reproduced musical sounds, but was only able to convey speech to a very limited extent. Reis was well aware of the importance of his invention, which at the time was treated as toy, and on one occasion remarked "that he had shown to the world a road to a great discovery, but left it to others to follow it up." Bell's first telephone consisted of a stave harmonica fastened to the poles of a permanent magnet with an electromagnet placed in front. The expense of such an apparatus prevented Bell from developing and perfecting the idea. His second telephone was the next instrument brought out, and for which a patent was taken out early in 1876. About the same time Elisha Gray also requested a patent for his telephone. A dispute arose between Bell and Gray about the patent of the vibrating membrane, which was decided in favour of Bell. The third telephone of Bell's was the form exhibited at the Philadelphia Exhibition in 1876, and this was the instrument which so much astonished Sir W. Thomson when he first saw it. The first practical magnetic telephone was exhibited early in 1877 in Salem, Massachusetts, by Bell, when a speech delivered in Boston was heard by an audience in Salem. Before the telephone could be brought to the commercial importance that it at present enjoys there was still a problem to be solved, the solution of which was effected by Hughes's discovery of the microphone; for although the principle involved in the microphone had been announced years before by Du Moncel, Hughes was the first to systematical y investigate the subject, but Edison appears to have been the first to construct a carbon transmitter in 1878. The difference between Edison's carbon transmitters and Hughes's microphone, in its simple form, was very slight, the object of both being to amplify the currents. The effect of the discovery of the microphone upon telephony was incalculable, and in the same way as all the numerous magnetic telephones are, more or less, imitations of Bell's original telephone, so all carbon transmitters are modifications of Hughes's invention. The number of these imitations is legion; many of them are without practical value, whilst others have given in practice superior results to the inventor's apparatus by enabling the listener to hear the words more distinctly. I will not inflict you with anything like an enumeration of the many different patterns of telephones which have been offered to the public since Bell's first discovery, or attempt to describe even the more salient points of difference between them. The principle involved in one and all is the same. The theory of the telephone has given rise to much controversy, and it will probably continue to be an interesting subject for discussion. Several explanations have been given to account for the actions and reactions which take place between the diaphragms of the transmitter and receiver. Some hold that the currents developed in a Bell telephone are much too feeble to account for the effects produced in the diaphragms of the receiver, if these effects are to be attributed to attraction pure and simple, and that molecular disturbances in the mass of the bar bear an important part in causing the vibration in the diaphragm. Whether this be so, or whatever the cause of the action may be, the instrument remains marvellous in its simplicity and astounding in its results. One of the latest applications of the telephone is that in which it is used as a telegraph receiver—in Mr. Langdon Davies's system, and to which he has given the name of "The Phonophore." Unlike in principle as are telephone and the ordinary Morse systems of telegraphy, yet by means of this ingenious instrument Mr. Davies has devised a means whereby both the telephone and the Morse are worked simultaneously on the one wire. The arrangement is likely to be largely used, and this is another instance of the inventive genius of the age. With the introduction of the telephone a world of research has been opened up, of the existence of which we were previously unaware. Hughes's induction balance has applied the telephone to a field of investigation of which we have hitherto been ignorant. Does it not seem wonderful, for instance, that we should be able to detect internal flaws in the mass of an iron rail, or in the case of a steel shell? And yet by an ingenious application of Hughes's induction balance in an instrument to which has been given the name of the "Schiseophone," it is now possible to pick out, by the aid of the telephone, flaws in a mass of metal which defy detection by any other means. Another appliance which depends for its action upon the principle of the induction balance is Captain M'Evoy's torpedo detector. As its name implies, it is designed for use in searching for submarine mines in harbours and channels. One portion of the balance, enclosed in a metal sinker, is attached to a small cable which is in connection with the telephonic portion of the apparatus in a boat. The sinker is dragged along the bottom of the channel where mines are suspected to have been laid. No sound is audible until the sinker reaches the vicinity of a mine, when a buzzing noise is heard in the telephone, which gradually increases as the mine is approached, and is loudest when it is touched. Medical science has also made use of the balance, and, as you will well remember, such an instrument was used in the case of the late President Garfield, by Prof. Graham Bell, to discover the position of the bullet. It is not to be wondered at that an instrument of such marvellous sensitiveness as the telephone should have been made use of to enable the faintest pulsation of the heart, of the pulse, and the arteries to be heard, and even to detect the normal muscular sound, and the characteristic rumbling noise when contraction of the muscles take place. I cannot leave this portion of my subject without alluding to the phenomenal commercial development of the telephone that has taken place within the last few years. In the arrangement of a telephone exchange every minute detail has been carefully thought out and provided for, and the general public have little idea of the mechanism required to enable "Smith" to ring up and talk to "Jones." The distance limit of telephonic communication is gradually being extended. New York has spoken to Chicago over 1,000 miles of wire, and the recent connection of London to Paris brings to mind Proctor's prediction "that a whisper would ere long pass beneath the Atlantic Ocean which none of the waves would drown." We are still as far from this imaginary consummation, but a beginning has been made. The rapid development of the telephone since its discovery is unique in the annals of science; it shows the increasing importance of science for the progress of civilisation and the immense import of Prof. Graham Bell's discovery. Every day witnesses new experiments, new problems for the solution of which the telephone affords a means of investigation. But new difficulties also arise from its application, the most serious of which is the well-known induction trouble—a difficulty of so serious a nature as at one time to threaten the development of the system. This trouble has been to a certain extent overcome by different means, but not in an altogether satisfactory manner; and as the spread of cables and leads carrying powerful currents required for motive power and lighting purposes increases, so does the necessity for united action become more apparent, if the greatest amount of good is to be obtained from each and all of the different modern applications of electricity. The natural sequence to the discovery of an instrument enabling us to detect sounds otherwise inaudible, was an instrument to enable us to record those

sounds. Such an apparatus was supplied by Edison when, in 1877, he introduced the phonograph, which created considerable sensation at the time. I mention the phonograph because of its close relationship to the telephone, not that electricity is concerned in its action, except in so far as the motive power is concerned, but also because it proves that the oscillations of a tympanum, like the disc of a telephone, are capable of producing all the effects of sound. There are something like 8,000 of these instruments at present in use in America, and it has even reached the "penny-in-the-slot" stage of existence, when music, song, and speech may be laid on tap, and, like a "Joe Miller" jest-book, tell the latest as well as the oldest good story. We have now to turn our attention to a branch of electrical engineering which has been even more rapid in its development and more universal in its use than almost any other. I refer, of course, to electric lighting and the use of electricity as a motive power. In this, as in other branches, there are many claimants for the honour of having been the first to make electric lighting a commercial success, and in this also we must finally come to the conclusion that the whole edifice has been built up, each inventor and discoverer depending for his ultimate result upon an experiment performed by some earlier investigator. I think we may fairly consider Faraday's discovery in 1832 of the principle of electromagnetic induction as being the foundation of modern commercial electric lighting, followed so quickly in 1833 by Pixii's magneto machine, which again was rapidly improved upon by Clarke, whose machine is still in common use for medical coils. The next notable incident was the invention by Dr. Werner Siemens, in 1857, of the well-known "H" armature, which was constructed of this shape so that the coils might revolve in the most powerful part of the magnetic field—a considerable advance on the instruments of Pixii and Clarke, in which the coils merely moved in front of the poles of the magnet. Next we have Wilde's machine, in which a small auxiliary magneto machine was used to produce a current for the purpose of exciting the fixed magnets of a larger machine with electromagnets instead of permanent magnets. And finally, we come to the true dynamo-electric principle. Hjorth in 1854 took out a patent for a machine which was near in principle to the modern machine; in it he had both permanent magnets and electromagnets and one armature. About the end of the year 1866 and the beginning of 1867 we find three claimants for the invention of the modern dynamo. Mr. S. A. Varley, who filed his provisional specification on December 24, 1866; and in February, 1867, Dr. C. W. Siemens and Sir Charles Wheatstone both announced the discovery independently at the same meeting of the Royal Society. In 1860 a further advance was made by Dr. Pacinotti, of the University of Pisa, who invented the ring type of armature. Curiously enough, his original machine, which was invented as a motor, had electromagnets for field magnets; and in his description Pacinotti states that the machine may be used to generate a current by substituting permanent magnets for electromagnets for the field. It was not until 1871 that Gramme invented his well-known ring form of armature, which still is used, with slight modifications, in most modern dynamos, such as the Manchester, Crompton, Paterson and Cooper, Brush-Victoria, and Hochhausen. The drum armature, which with various modifications we see used in the Siemens, Edison, and Weston machines, was invented by Von Hefner-Alteneck in the following year. Having followed the discovery of the dynamo-electric machine, we must retrace our steps to the year 1810, when Davy showed an arc light at the Royal Institution, using a battery of some 2,000 cells for the purpose. From this time until the discovery of the dynamo but little development took place owing to the excessive cost of producing sufficient current by means of batteries. In 1857 Serrin, and in 1858 Foucault, produced arc lamps in which the adjustment of the carbons was brought about automatically; but no real advance appears to have been made until 1876, when the Jablochkoff candle was invented, and with the help of the dynamo came into fairly extensive use for a time, though in 1858 an arc light driven by a Holmes magneto machine was installed in the South Foreland, and in 1862 in the Dungeness lighthouses. The Jablochkoff candle was soon discarded for the self-regulating arc lamp, of which those in most extensive use at present are the Brockie-Pell and Thomson-Houston. Useful as the arc lamp is for lighting streets, open spaces, and large buildings, it is entirely unfit for general domestic illumination, and consequently the attention of many inventors was drawn to the necessity of what at that time was termed "the subdivision of the electric light." At a very early period it was perceived that for this purpose the most promising method was the heating to incandescence of a continuous conductor, and platinum, and similar metals having a high melting point, were the first substances to be experimented with. We find, in 1845, an American named Starr took out a patent for a carbon lamp sealed into the vacuum chamber of a barometer tube. Then, in 1848, W. E. Staite took out a patent for making electric lamps of iridium, shaped in a horseshoe form. Up to 1878 very little improvement was made. In that year Sawyer and Man made their first lamp of carbonised paper. Edison, who in the following year took out patents, not only for an incandescent lamp, but for a system of electric lighting, is generally credited with having made electric lighting commercially successful. But I think that you will agree with me that due credit should be given to the other investigators in the same line of research—such as Sawyer and Man, Swan, Maxim, and Lane Fox, more especially to Swan, and Sawyer and Man. In 1883 a great advance was made by Gaulard and Gibbs, in the invention of their high-tension alternate-current transformer, which enabled electricity to be transmitted to much greater distances than could ever be achieved by continuous currents, a notable instance of which is the present experiment of transmitting power from Lauffen to Frankfort, a distance of over 100 miles, by means of high-tension alternating currents. The transformer is a direct descendant of the induction coil as first used by Faraday, and afterwards improved by Rhumkorff. As in former cases, Gaulard and Gibb's transformer has received many improvements at the hands of such men as Mordey, Zipernowski, Ferranti, Kapp, and others. The first central station in London, known as the Grosvenor Gallery Station, used Gaulard and Gibbs's transformers in 1885, and was the forerunner of the now famous Deptford station, constructed to use a pressure of 10,000 volts. For another important discovery in connection with electrical engineering, we must go back again to Planté's discovery, in 1859, and Faure's subsequent improvement, in 1880, of the secondary battery. In 1888, there were in England but eight central stations, with a total of 27,000 incandescent lamps in use. At the end of 1890 there were 48 stations, with a total of about 530,000 incandescent lamps in use, and a total ultimate provision for over a million. In America we find a more widespread use of electricity as an illuminant, as at the end of 1888 we find some 204 towns using an aggregate of over 5,000 arc lamps and 250,000 incandescent; in January of the present year there were 1,674 central stations at work, with an aggregate of over a million incandescent and over 30,000 arc lamps in use. I do not see that we are going ahead quite so fast in either Great Britain, Europe, or Australia. Still another modern development is the use of electricity as a motive power. As far back as 1830 Prof. Negro, of Padua, constructed an electric motor, using permanent and electro magnets; Jacobi, in 1834, used an electromotor, consisting entirely of electromagnets, to propel a boat on the Neva; in 1835 Stratingh and Becker, of Gruningen, and Botto, of Turin, constructed primitive electric cars, and Thomas Davenport, of Brandon, U.S.A., built a small circular railway at Springfield, Massachusetts; and amongst these early pioneers we must also mention Davidson, a Scotchman, who in 1838 built an electric car weighing five tons, with which he obtained a speed of four miles an hour. Elias in 1842 constructed a motor, having a Pacinotti ring for its armature, and we find various forms of motors invented by Froment, Hjorth, Page, Farmer, and others, with very little commercial advance, until the invention of the dynamo and the discovery of its reversibility. The first successful experiment was made with the electric railway exhibited by Siemens at the Berlin Exhibition in 1879. In England there is the underground City and South London Railway; and several others, besides the extension from Stockwell to Clapham underground, and the Liverpool Overhead, and others in progress; also many on the Continent of Europe. The present period has been, I think, very properly termed the "electric age." Incandescent and arc lamps greet us at every turn; no business office is now complete without its telephone, the sending of telegrams or cablegrams is of no more import nowadays than posting a letter, electric bells are in every modern-built house, a ride on a car driven by electricity is no longer an event to be remembered, and we see and hear of electric motors being used for all manner of purposes in many different trades; for driving lathes, sewing machines, printing presses, fans, pumps, lawn-mowers, for blowing organs, heating railway carriages, for mining drills and coal-cutters, riveting machines, welding, and a host of other purposes far too numerous for me to mention here. The recent legalisation in the United Kingdom of the volt, ohm, and ampere is in itself a distinct proof of the familiarity with which electrical matters are treated in modern times. I have spoken of the past and present; I feel that I shall have hardly completed my task without taking a peep into the future. We read of the phonograph, telephone, telegraph, etc., having been foretold or prophesied long ago; without, perhaps, going so far as to make such distinct prophetic utterance, we can at least imagine a time not very far distant when the telephone will become universal, not only commercially but domestically, when there will be intercolonial and even international exchanges, and the telegram and cablegram a thing of the past; when at the same we are speaking through the telephone from here, perhaps to London, we shall at the same time see the form and face of the listener at the other end. Do not laugh, gentlemen; you would have laughed 100 years ago if you had been told what we should possess in the way of scientific inventions now. When we shall have air and water

ships propelled by electricity generated by a thermo-battery, burning coal instead of decomposing zinc; a time when electricity is the only motive power in existence; and when, by the development of Tesla's experiments, instead of lighting our rooms by points of light we shall have the whole of the atmosphere in a state of luminosity; when, instead of suffering from alternate droughts and floods, we shall be able to regulate and control the rainfall by means of the electric discharge—a period in which fogs will be dispersed electrically immediately on formation, and in which we shall be able to cure all disease by the aid of this potent agent, when electricity has been applied to such an extent in warfare that war without annihilation becomes impossible, and we have obtained the millennium of peace. In this address I have endeavoured to place before you some of the more remarkable developments of electrical science from the early philosophical experiments to the practical realisation of those experiments by modern inventors, who have adapted them to the requirements and comfort of the present age, and I have even attempted to see even the further developments which have yet to be made. This I have endeavoured to do without going into those minor details which are familiar to most of you, and which would extend this paper to a wearisome length. The world has seldom seen such a period of scientific unrest as the last 20 years, both in America and Europe, but of the multitude of discoveries and inventions which have been the product of that period, there are few which have been made by mathematical leaders. Most of them may be regarded as the results of investigation not of the learned few, but of the fortunate few of the comparatively unlearned many.

At the conclusion of the speech a vote of thanks was accorded to Mr. Cracknell, on the motion of Mr. H. H. Kingsbury, seconded by Captain F. C. Rowan, and the proceedings closed.

COMPANIES' MEETINGS.

EDINBURGH ELECTRIC SUPPLY CORPORATION.

The second annual general meeting of the shareholders of this Corporation was held recently in 17, St. Andrew-square, Edinburgh. Mr. Walter Berry, of Glenstriven, chairman, presided.

The report stated that there were now 206 shareholders enrolled on the list, amongst whom were a large number of prominent citizens of Edinburgh and Leith, representing a privately subscribed capital of £31,175, which places the Corporation in a very strong position locally, and the share list was daily becoming more influential. Reference was made to the negotiations entered into by the Directors with the Town Council, setting forth the position of the Company and the advantages that would result to the city were an arrangement arrived at whereby the lighting of the compulsory area comprised in the provisional order should be undertaken by it. The subject, the report continued, must shortly be considered by the Councillors, as they obtained the Royal assent to their provisional order in the beginning of last July, from which date they had only three years to complete this work within the compulsory area. Meantime, the Directors had collected a large mass of information and statistics connected with similar works, finished and in progress, throughout the United Kingdom and elsewhere, which would enable them to tender for the electric lighting of the city, should the Town Council decide on delegating their powers to the Company. In the meantime the shareholders had incurred no liability with regard to the expenses, nor would they do so unless the desired contract was obtained from the Council, when the shares would be issued to the public, and the business of the Corporation be at once proceeded with.

The **Chairman**, in moving the adoption of the report, said he had to express the regret the Directors felt in being still unable to intimate any progress towards the definite fulfilment of the object for which the Company was formed, but no one was to blame for that. Without being too pressing, the Directors had not failed to urge their claims on the Town Council, and he could not doubt that these would be favourably considered when the Council was in a position to come to a decision. They must, of course, recognise that their representatives in the Council might decide that in the public interest it would be preferable for them to undertake the work themselves, and he had no doubt that should they so decide, their decision would be arrived at on sufficient grounds. In that case the existence of their Corporation would terminate, and the preliminary subscriptions of the shareholders would be returned in full. As they were aware, the reasons why this Company was originally formed were—first, that it was deemed that there was sufficient business capacity in Edinburgh to carry out the electric lighting of our city, and that there was sufficient public spirit to form a local company for that object; secondly, that they objected very strongly to be tied to any one system. They knew that the Company against which they appeared as competitors was limited to its own special method, against which he had not one word to say. It might still prove the best, but they thought it well worth the trouble involved to attempt to keep the city free to adopt the best obtainable. Therefore, if the city entrusted the electric lighting of Edinburgh to their Company, they should do their best to keep in the front rank, both scientifically and practically. Great strides had been made within the last year in electric lighting. The recent Frankfort Exhibition had brought many useful adaptations and inventions before the public, and although it would be foolish not to recognise that many more would be discovered, they could not wait indefinitely for that. They had, at any rate, the advantage of studying many failures and mistakes, and would profit by them. He felt confident that if the Company were entrusted with the work it would be done as well as the present position of the science would admit. They were naturally anxious to have the business, but the shareholders might rest assured that although their Directors would not be greedy for profit, they would not undertake any contract which did not in their view leave a good margin for interest and risk.

Mr. George Barclay said he had great pleasure in seconding the adoption of the report, because he thought both the report and the Chairman's remarks indicated that the Directors had been proceeding on wise and prudent lines, and that being so there was good reason to believe that should the Corporation eventually succeed in getting the concession from the city on fair and reasonable terms, the same Directors would carry out the enterprise to a successful termination.

The report was adopted unanimously, and on the motion of **Sir Thomas Clark** a vote of thanks was passed to the Chairman.

MUTUAL TELEPHONE COMPANY.

Directors: A. D. Provand, M.P., London, chairman; H. T. Gaddum, J.P., Manchester; W. M. Mollison, Manchester; Councillor J. W. Southern, J.P., Manchester; John Blyth, Liverpool; James R. Paton, Liverpool. A. R. Bennett, M.I.E.E., general manager. J. Vincent Swindells, secretary.

Report of the Directors for the period ending 31st October, 1891, presented to the shareholders at an ordinary general meeting of the Company, held at the Memorial Hall, Albert-square, Manchester, on Thursday, the 31st ult.

The Directors have the pleasure of submitting to the shareholders their first report and statement of accounts, made up to the 31st day of October, 1891. The accounts do not represent an ordinary working period, but must be submitted in order to conform to the requirements of the articles of association. The capital account shows that from the formation of the Company to the 31st October, 1891, the sum of £21,539. 2s. 6d. has been expended on the construction of the Company's exchange system in Manchester, and that £1,574. 16s. 8d. has been expended in other places where it is proposed to open exchanges. The revenue account represents only a working period of four months—viz., from July 1st to October 31st, 1891, the former being the date from which, with the exeception of £191. 15s. previously charged, the Company commenced to earn revenue. This account shows a gross rental of £3,906. 5s., of which £1,145. 1s. is applicable to this period, and £2,761. 4s. has been carried forward to next account as representing rentals received in advance for periods extending beyond 31st October, 1891. The amount at the credit of the account is £378. 11s. 7d., which the Directors propose to carry forward. The business of the Company is proceeding in a very satisfactory manner. At the date of this report, 840 instruments are in connection with the Company's exchange. This leaves a large number of applicants still to be joined up, while additional applications are being received daily. Attention is also being given to the work of connecting by trunk wires the various manufacturing centres around Manchester, and your Directors hope before long to offer to the subscribers these facilities. Arrangements have been made to open call-boxes on the main boards of the Royal Exchange, and these will shortly be ready for the use of subscribers to the Company's system The Directors feel that they may congratulate the shareholders upon the Company having already proved itself an accomplished success, both in respect of the advantage of the metallic circuit (*i.e.*, the double wire), as affording clearness of speech, and as confirming the views held by the promoters of the Company that a telephone service, worked with the most modern improvements, can be supplied at rates much below those hitherto charged. The retiring Directors are Messrs. Provand and Southern, who, being eligible, offer themselves for re-election. The auditors, Messrs. Thomas, Wade, Guthrie, and Co., also retire, and are eligible for re-election.

Revenue Account, covering the working period of four months ending October 31st, 1891.

Dr.				£	s.	d
Rents, rates, insurance, and wayleaves..................				202	4	11
Working expenses—						
Including expenses of management, office salaries and expenses, and operators' wages				474	10	7
Repairs to lines and instruments				42	14	7
Balance carried forward				378	11	7
				£1,098	1	8
Cr.	£	s.	d.	£	s.	d.
Rentals—						
Received and outstanding	3,906	5	0			
Less proportion in respect of periods extending beyond October 31, 1891..............................	2,761	4	0			
	£1,145	1	0			
Deduct—						
Post Office royalties......	107	18	6			
				1,037	2	6
Bank interest				60	19	2
				£1,098	1	8

BALANCE-SHEET, OCTOBER 31, 1891.

Dr.	£ s. d.	£ s. d.
Construction account—		
Amount expended since the commencement of the Company on the construction of the exchange and private lines and other capital charges	20,359 15 9	
Preliminary and formation expenses	1,179 6 9	
		21,539 2 6
Amount in suspense for legal and professional charges		636 19 8
Preliminary expenses in districts where it is proposed to open exchanges		1,574 16 8
Stores, apparatus, tools, etc.		6,105 6 1
Office furniture		300 12 11
Sundry debtors (for outstanding rentals)		538 12 6
Post Office royalties and other payments in advance		329 8 10
Cash in bank and in hand		948 6 8
		£31,973 5 10

Cr.	£ s. d.	£ s. d.
Capital, £350,000—		
Present issue 4,092 shares of £10 each with £6 per share paid	24,552 0 0	
Less arrears of calls	1,332 0 0	
	23,220 0 0	
Add amount paid in advance of calls	556 0 0	
		23,776 0 0
Sundry creditors		5,057 10 3
Proportion of rentals for periods beyond October 31, 1891, as per revenue account		2,761 4 0
Balance at credit of revenue account		378 11 7
		£31,973 5 10

The ordinary meeting of the Company was held at Manchester on the 31st ult., Mr. Provand occupying the chair.

The **Chairman**, in a few words, referred to the work they had accomplished in the short period since they began operations, and proposed the adoption of the report and accounts.

This was duly seconded, and carried unanimously, several shareholders expressing gratification at the satisfactory state of the Company.

The retiring directors, Messrs. Provand and Southern, as well as the auditors, Messrs. Wade, Guthrie, and Co., having been re-elected, the proceedings closed with a hearty vote of thanks to the Chairman and Board.

NEW COMPANIES REGISTERED.

Central Electrical Company, Limited.—Registered by T. T. Hull, 22, Chancery-lane, W.C., with a capital of £50,000 in £1 shares—5,000 preference and 45,000 ordinary. Object: to carry into effect an agreement expressed to be made between Knud Sande of the one part and this Company of the other part, and generally to carry on business as electricians, mechanical engineers, suppliers of electricity for the purposes of heat, light, motive power, or otherwise, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity; to construct, lay down, establish, fix, and carry out all necessary cables, wires, lines, accumulators, dynamos, batteries, lamps, meters, works, and to generate, accumulate, distribute, and supply electricity, and to light streets, markets, houses, buildings, and places, both public and private. The first subscribers are:

	Shares.
P. H. H. Nickson, 221, Gipsy-road, West Norwood	1
H. W. Britt, Bourneside, Weybridge	1
T. Hallamore, 340, Old Broad-street, E.C.	1
J. P. O'Donnell, 2, Great George-street, London	1
K. Sande, 47 and 48, Broad-street-avenue, E.C.	1
W. Woodhead, 4, Station-buildings, West-green, Tottenham	1
H. B. Thurston, 50, Norwood-road, Herne Hill	1

There shall not be less than three nor more than seven Directors; the first are to be appointed by the signatories to the memorandum of association. Qualification, £100. Remuneration, £100 per annum each, with an additional 10 per cent. of the net profits, divisible as to the latter.

Keighley Electrical Engineering Company, Limited.—Registered by Ullathorne, Currey, and Villiers 1, Field-court, Gray's-inn, W.C., with a capital of £10,000 in £1 shares. Object: to adopt and carry into effect an agreement, made October 27, between H. Boardman of the first part, I. Ickringill of the second part, C. J. Garnett of the third part, A. Moore of the fourth part, C. H. Seed of the fifth part, and S. Hey of the sixth part, for the acquisition of the business of C. J. Garnett, now carried on at South-street, Keighley, and generally to carry on business as electrical engineers in all its branches. Registered without articles of association.

BUSINESS NOTES.

Great Northern Telegraph Company.—The receipts for the month of December were £22,400.

Eastern Telegraph Company.—The receipts for December were £55 830, as against £58,058 for the same period of 1890, a decrease of £2,228.

Eastern Extension Telegraph Company.—The receipts for December amounted to £38,898, as against £43,482 in the corresponding period, showing a decrease of £4,584.

City and South London Railway.—The receipts for the week ending January 3, 1892, were £878, as against £805 for the corresponding week last year, showing an increase of £73, and an increase of £7 as compared with the receipts for the week ending December 27, 1891.

The Direct United States Cable Company recommend an interim dividend of 3s. 6d. per share, tax free, being at the rate of 3½ per cent. per annum, for the quarter ending December 31st, 1891, payable on the 23rd inst. £5,000 has been placed to the reserve fund, and £4,982 carried forward.

Partnership.—Mr. Smeeton and Mr. Page have entered into partnership, trading as Messrs. Smeeton and Page, at 63, Queen Victoria-street, E.C. Mr. Smeeton was a pupil of Messrs. Goolden and Trotter's, and has since acted as engineer to the General Electric Company on their foreign installations. Mr. Page was manager of the same firm's supply department.

Change of Address.—Mr. G. E. B. Pritchett, of 1, Hanway-place, Oxford-street, W., informs us that he has removed to 31, Soho-square, W., and that he has taken his brother, Mr. T. W. Pritchett, late of the Metropolitan Electric Supply Company, into partnership. In future the business will be carried on at the above address under the title of Pritchett Bros.

Companies Registered during December.—The following electrical companies were registered during the past month:

California Gas, Water, and Electric Light Syndicate, Limited. £1 shares	£2,000
Chloride Electrical Storage Syndicate, Limited, £1 shares	262,500
Central Electrical Company, Limited, £1 shares	50,000
Keighley Electrical Engineering Company, Limited, £1 shares	10,000
Lightning, Limited, £1 shares	3,000
Mountain's Wire Manufacturing Company, Limited, £5 shares	25,000

PROVISIONAL PATENTS, 1891-92.

DECEMBER 21.

22,284. **An improved device for suspending electric cables or conductors.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

22,301. **An improved method of lighting railway carriages by electricity.** Sarah Jane Rollason, 50, Goldhurst-terrace, South Hampstead, London.

22,304. **Improvements in means of electric transmission for telegraphic, telephonic, and other purposes.** Silvanus Phillips Thompson, the Technical College, Leonard-street, Finsbury, London.

22,316. **Improvements in electrical distribution and transformers therefor.** Joseph Devonport Finney Andrews, 28, Southampton-buildings, London.

22,326. **Improvements in Wheatstone bridge apparatus and in the adaptation of the same to the measurement of temperatures, electric, potential, and current.** Hugh Longbourne Callendar, 24, Southampton-buildings, London.

22,339 **Improvements in primary and secondary batteries.** Nicholas Wladimiroff, 4, South-street, Finsbury, London.

DECEMBER 22.

22,352. **Improvements in electric switches.** Gwynne Ernest Painter, 11, Wellington-street, Strand, London. (Complete specification.)

22,360. **An arrangement for securing good contact in electric switches, and for avoiding dead stops in their action.** Joseph Jackson, 21, Fernhead-road, Paddington, London.

22,370. **Improvements in nautical signals or sea telephones.** Ernest Huber, Frederick Jacob Kneuper, and James Robert Davies, 321, High Holborn, London. (Complete specification.)

22,375. **Improvements in shades for gas, electric, and other lights, and in the mode of manufacturing the same.** Amédée Bidron and William Isaiah George Lewis, 38, Chancery-lane, London.

22,376. **Improvements in switches for electrical purposes.** Charles Scott Snell, and Woodhouse and Rawson, United, Limited, 88, Queen Victoria-street, London.

22,404. **Improvements in the coupling of electric mains.** Henry White Bowden, Albert Gay, and Robert Hammond, 46, Lincoln's-inn-fields, London.

DECEMBER 23.

22,473. **Improvements in electrical heating apparatus.** Carl Drevs, 323, High Holborn, London. (Complete specification.)

22,478. **Improvements in the construction and working of electric accumulators.** Illius Augustus Timmis, 2, Great George-street, Westminster, London.

22,482. **Improvements in voltaic cells.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward Weston. United States.) (Complete specification.)

DECEMBER 24.

22,507. **Improvements in supports for telephone receiving instruments.** Robert Atkins Fraser and George Frederick Rowland Kelson, 4, Clayton-square, Liverpool.

22,533. **Combined portable electric lamp and battery, which may also be applied to act as a burglar alarm.** Thomas Jenner, 77, Chancery-lane, London.

22,542. **Improvements in devices for conducting electricity to lamps or the like on dining-tables or on other places where it is desirable to employ concealed conductors.** George Phillips, and George Fitzhardinge Rose, 47, Lincoln's-inn-fields, London.

22,554. **Improvements in batteries and accumulators.** Henry Harrington Leigh, 22, Southampton-buildings, London. (Johann Franz Weyde and Ferdinand Clas, Austria; and Jules Elsner, France.)

22,555. **Improvements in dynamo-electric machines.** Alexander Bernstein, 4, South-street, Finsbury, London.

DECEMBER 28.

22,575. **Improvements in dynamo-electric machines.** Rankin Kennedy, Carntyne Electric Works, Shettleston, Glasgow.

22,576. **Improvements in alternating-current generators and electromotors.** Rankin Kennedy, Carntyne Electric Works, Shettleston. Glasgow.

22,582. **Improvements in ceiling joints for electroliers and the like.** George Frederick Sanders, 37, Chancery-lane, London.

22,593. **A combined telephone and telegraph.** Frederick Harvey Brown and Wilbur F. Melbourne, 7, High-street, Haverfordwest.

22,605. **Improvements in conduits for electrical conduct rs particularly suitable for electrical traction.** Charles Frederick Parkinson, South Regent-street, Lancaster.

22,609. **Improvements in incandescent electric lamps.** Richard Ballard, 2, Clifford's-inn, London.

22,627. **Improvements in electric locomotives or electric-motor cars.** Sidney Pierce Hollingsworth, 24, Southampton-buildings, London.

22,636. **Improvements in electrical conducting wires.** Henry Harris Lake, 45, Southampton-buildings, London. (Madame Veuve Hannetelle, *née* Hortense Chapuis, France)

22,640. **Improvements in electric arc lamps.** William Brooke Sayers, 46, Lincoln's-inn-fields, London.

DECEMBER 29.

22,686. **Improvements in electric forges.** Edwin Elliott Angell, 52, Chancery-lane, London. (Complete specification.)

22,687. **Improvements in electric blank heaters for forging machines.** Edwin Elliott Angell, 52, Chancery-lane, London. (Complete specification.)

22,695. **Improvements in apparatus for relieving electrical circuits from static charges of electricity.** Oliver Imray, 28, Southampton-buildings, London. (The Westinghouse Electric and Manufacturing Company, United States.)

22,708. **Improvements in the manufacture of porous carbon for galvanic batteries and for filters.** Wilhelm Hellesen, 4, South-street, Finsbury, London.

22,718. **Improvements in machines for treating metals by electricity.** George Dexter Burton and Edwin Elliott Angell, 45, Southampton-buildings, London. (Complete specification.)

22,720. **Improved methods of and apparatus for heating metal articles by electricity.** Edwin Elliott Angell, 45, Southampton-buildings, London. (Complete specification.)

22,725. **A new or improved method of making and breaking electric circuits and apparatus therefor** William Henry Dingle and John Mackenzie Urquhart, Norfolk House, Norfolk-street, London.

DECEMBER 30.

22,773. **Improvements in and relating to electric bells and indicators.** Charles Fletcher Ennis, 31, Haselrigge-road, Clapham, Surrey.

22,782. **Improvements in electric arc lamps.** Guy Carey Fricker, 46, Lincoln's-inn-fields, London. (Complete specification.)

22,785. **Improvements in the field magnets of dynamo-electric machines.** Lazarus Pike and Edward Stephen Harris, 433, Strand, London. (Complete specification.)

DECEMBER 31.

22,817. **Improvements in dynamo-electric machines.** John Hall Rider, Northern Telegraph Works, Halifax.

22,820. **Improvements in connection with telephones.** Ernest Frank Furtado, Anders Elliott, and Chetham-Strode, Ld., 4, Moorfields, London. (Complete specification.)

22,837. **Improvements in electric arc lamps.** Hubert Hallam Bigland and John Burns, 6, Lord-street, Liverpool.

22,852. **Improvements in and relating to electric meters.** Francis Teague, 433, Strand, London.

22,854. **Improvements relating to the electrolysis of metals.** Emile Placet and Joseph Bonnet, 6, Bream's-buildings, London. (Date applied for under Patents Act, 1833, sec. 103, 17th July, 1891, being date of application in France.)

22,855. **A method of extracting chromium by the aid of electrolytic baths with a base of salts of chromium** Emile Placet and Joseph Bonnet, 6, Bream's-buildings, London. (Date applied for under Patents Act, 1883, sec. 103, 17th July, 1891, being date of application in France.)

22,856. **A method of extracting chromium by the aid of electrolytic baths with chromic acid base.** Emile Placet and Joseph Bonnet, 6, Bream's-buildings, London. (Date applied for under Patents Act, 1883, sec. 103, 17th July, 1891, being date of application in France.)

22,858. **Improvements in or connected with electrical measuring and indicating apparatus.** Erhard Ludwig Mayer, Norfolk House, Norfolk-street, London.

22,871. **Improvements relating to the employment of electricity when carrying out certain surgical operations.** John Jones Attwood, 20, High Holborn, London.

22,872. **Rietti system of electric tubing.** Charle William Clement Rietti, 14, Glasshouse-street, Regent-street, London.

JANUARY 1, 1892.

37. **Improvements in electric tricycles and cars actuated by electricity.** William Walter Gerald Webb, 9, Coppenhall-terrace, Crewe.

43. **Improvements in apparatus for electric lighting of railway trains.** Edward John Houghton and William White, 28, Southampton-buildings, London.

JANUARY 2.

86. **Improvements in electrical railways and methods of and means for driving cars and transmitting electrical energy thereto.** Francis Beatus Badt, 1, Quality-court London.

97. **Improvements applicable to the production of electric light in walking-sticks and other similar articles** Samuel Harris Levi, 115, Cannon-street, London.

SPECIFICATIONS PUBLISHED.

1890.

19,811. **Propelling vessels by electricity.** Wynne. 8d.
20,175. **Electric meters.** Frager. 8d.
20,360. **Electric meters.** Electric Meter Company and Parker. 8d.

1891.

105. **Electric conductors.** Haselwander. 8d.
285. **Telephonic transmission.** Mayer. 8d.
1,779. **Electric motors, etc.** Hartnell. 8d.
2,067. **Electrical transformers.** Baur and Dieselhorst. 4d.
3,262. **Electrical glow lamps.** Gimingham. 6d.
3,398. **Electrical burglar alarm.** Spencer. 6d.
4,583. **Electric supply meters.** Perry. 8d.
10,840. **Electric clocks.** Vander Ploeg. 6d.
14,911. **Telephone receiver supports.** Marcus. 6d.
14,912. **Telephone mouth-piece.** Marcus. 6d.
16,767. **Electric cooking and heating.** Schindler Jenny. 8d.
17,107. **Electric arc lamps.** Rider. 6d.
17,734. **Electric switches.** Linders. 6d.
18,431. **Secondary batteries.** Waddell and others. 8d.
18,641. **Dynamo-electric machines.** Kelly. 6d.
18,902. **Electric conductors.** Redfern. (Bergmann.) 6d.
18-916 **Electric car trollies.** Nuttall. 6d.
19,458. **Electric accumulators.** Thompson. (Edgerton). 6d.
19,469. **Telephones** Grove and Lehr. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3⅜
— Pref.	—	2⅛
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	10
London Electric Supply	5	1⅜
Swan United	3½	4¼
St. James'	—	8⅞
National Telephone	5	4½
Electric Construction	10	6¼
Westminster Electric	—	6⅝
Liverpool Electric Supply	5	5⅛
	3	2⅝

NOTES.

Johannesberg is now lighted by electricity.

London Tramway Company.—A motion for the use of electric cars was prepared at the meeting of this company, but was not put, as the directors were all averse to the change.

Railway Lighting in Germany.—The General Electricity Company of Berlin has been asked to contract for the electric lighting of the Berlin-Anhalt Railway, at a cost of some £30,000.

Factory Lighting.—Mr. R. Dann, of High-street, Maidstone, has executed the laying down of the plant for the use of the electric light in the jam factory of Mr. Chambers, at Maidstone.

Dover Telephones.—The town clerk of Dover reports that two telephone companies are seeking powers of the district, and he suggests that the Town Council should take action to secure their rights.

Long-Distance Telephones.—A Boston newspaper announces that the Bell Company has secured possession of an improved telephone which will transmit whispers distinctly a distance of 500 miles.

Book Received.—Messrs. Whittaker and Co. send us "Electric Light Cables and the Distribution of Electricity," by Stuart A. Russell, A.M.I.C.E., 107 illustrations, as the last addition to their "Specialists' Series."

Royal Institution.—The first of a course of three lectures will be given at the Royal Institution by Prof. J. A. Fleming on "The Induction Coil and Alternate-Current Transformer," on Saturday, January 23.

Hamilton (N.B.).—At the meeting of the Hamilton Town Council held last week, the further consideration of the question of extending the gas works was delayed, and enquiries were ordered to be made as to the introduction of electric light.

Leith.—At the monthly meeting of the Leith Dock Commission, the Finance Committee reported that they had instructed the superintendent to report as to the cost of the introduction of a complete system of electric lighting and the probable annual cost of maintenance.

Electric Boats.—The report of the French naval attaché in Italy states that an Italian inspector, Signor Pullini, has devised a launch driven by electricity, which has been adopted by the Italian Navy, and the construction is to be begun immediately at the works at Spezzia.

Blackpool.—The Electric Lighting Committee of the Blackpool Town Council have recommended that all the members of the committee, the town clerk, and the borough surveyor be desired to inspect the electric lighting in towns recommended by the sub-committee to be visited, and to make enquiries thereon.

Dover Lighting.—The town clerk reported at the last meeting of the Dover Town Council that he had received the draft agreement from the Brush Electric Light Company, which required some rather extensive alterations and additions before being placed before the Council. It was agreed to submit the alterations to the Council.

Electric Lighting in Ross shire.—By the utilisation of the water power of a small mountain stream, a mansion in Ross-shire is being lighted up by electricity. The stream is only 12in. wide and 4in. deep, but is made to provide current for 292 incandescent lamps, and for producing warmth through a series of electric stoves.

Chicago Exhibition.—Great progress is being made in the construction of the works and buildings for the World's Columbian Exposition, and it is confidently expected that all will be ready for the installation of exhibits by October 1, 1892—seven months before the exposition will open its gates to the public.

Reading County Ball.—At the last meeting of the Reading Town Council, the surveyor having reported, as to the feasibility of lighting the large Town Hall by incandescent lamps on the night of the County Ball, that the Reading Electric Lighting Company had offered to provide, fix, and light 15 50-c.p. lamps for £10, this offer was accepted.

Rochester.—In June last the Rochester, Chatham, etc., Electric Lighting Company had to take up new premises in Chatham, their land at Rochester being given up to the South-Eastern Railway Company. Water was wanted, and, after some considerable difficulty, on Saturday last Councillor R. D. Batchelor tapped the phenomenal supply of 20,000 gallons an hour.

Liverpool Town Hall.—Attention has been called to the fact that although in most large towns the electric light is the illuminating power used in the town hall, an important city like Liverpool has not adopted the system. An offer has been made by the Liverpool Electric Light Supply Company to light the town hall on certain specified terms, but the Finance Committee have postponed the consideration of the subject.

Electric Light from a Dumbartonshire Waterfall.—Mr. J. C. White, a wealthy Glasgow chemical manufacturer, is about to introduce the electric light into his mansion of Overtaun, near Dumbarton. A waterfall at Spardie Linn, in the Kilpatrick Hills, a short distance away, is to furnish the motive power. It is said that sufficient power could be generated at the same place to light the whole of Dumbarton by electricity.

Abdullah's Palace.—The variations in tenders for the Mansion House and the Council-chamber are as nothing to those found in the 20 tenders received recently for Abdullah's Palace at Alexandria, which varied from 192,000f. up to 600,000f. It is said that the tender of a German firm for the smaller amount has been accepted, and a considerable amount of vituperation has been going on in the Alexandria press with reference to this business.

Advantages of Competition.—In his report to St. Luke's Vestry, the surveyor, Mr. M. C. Meaby, remarks, under the head of public lighting, that "the keen competition which continues between the various gas and electric lighting companies is not without its advantage in the public interest, as may be seen by the activity displayed, and the large sums of money which are being expended by the various local authorities in rearranging and improving the lighting of the thoroughfares of their respective districts.'

Dr. Joule.—Prof. Schuster made an interesting communication at Tuesday's meeting of the Manchester Literary and Philosophical Society with reference to the late Dr. Joule's thermometers, which he has lately had the opportunity of inspecting and testing. Amongst them are two which there is good reason to believe are those with which Dr. Joule's most delicate heat experiments were made, and which have considerable scientific as well as historical interest owing to the change of value still observable in these thermometers.

Pontypool.—An influential meeting of tradesmen and others was held at The Crown Hotel last week for the purpose of considering the advisability of adopting electric lighting in the town instead of gas, as hitherto. Mr. Edwin Fowler presided. After hearing a statement from Mr. J. C. Howell, of the Crompton-Howell Company, Llanelly, as to the cost of the electric system, the meeting unanimously

decided in favour of the scheme, a committee being appointed to canvass the town with a view of ascertaining the probable number of lights required.

Stourbridge.—There is an opportunity at present for bringing the advantages of the electric light to the Stourbridge authorities. After March next the contract for public lighting will be revised, and the Board intend to advertise for tenders. They are now in the hands of the gas company, and there is no competition. The annual amount is £266 for 79 lamps, including lighting and cleaning. The question of oil was mentioned, and the gas company are understood to be able to offer advantages next year. A committee, consisting of Messrs. Collens, Worth, and Shepherd, was appointed to go into the matter and report.

Dublin.—In the Dublin Town Council on New Year's Day, the Lord Mayor, in reviewing the work of the past year, referred to the progress of the electric installation, and intimated that the building for the central station would be complete in a fortnight. His Lordship also stated that the principal streets would be lighted in May, and that the Corporation would be prepared to supply current to private consumers in July. The work of laying the street mains is being actively carried on by the Irish House-to-House Company, while the generating plant is being pushed forward by the Electrical Engineering Company of Ireland.

Tramways Institute. — On Friday evening the members of the Tramways Institute, which held its meeting at Bradford, visited the Roundhay Park electric tramway and the generating station in Beckett-street, in which, naturally, they were greatly interested. Some good results should come of this visit. Several papers were read during the meeting, one referring to electric traction, which we mention elsewhere. Another paper, by Mr. H. Nott Knight, described a system of driving tramcars by gas engines, by which it was claimed the cost of traction could be reduced to 1½d. per car mile, as against 6d. by steam and 5d. by horse traction.

Electrical Apparatus.—We have received the catalogue of electrical apparatus just issued by Messrs. Dollond and Co., of 35, Ludgate-hill. We understand that this department has been-opened under the management of W. F. Berrett, late manager to Messrs. Dale and Co. Added to the world-celebrated optical instruments of Dollond, their electrical apparatus will be very well worth inspection both by private students and authorities of electrical laboratories. The catalogue contains description and illustrations of induction machines, magnetic apparatus, batteries, coils, telephones, besides apparatus for use in research or for lecture purposes. The firm also construct special apparatus for lecturers.

Electric Meters.—Messrs. Ferranti have made some further improvements in their meters, principally to meet the requirements of the Board of Trade. A cover is arranged over the works of the meter, the screw holes of which can be sealed after testing and certificate; the meter connections have a further cover which can also be sealed when the meter is placed upon the customer's premises. These meters are very delicate, starting at less than ¼ ampere in a meter registering 100 amperes—400 per cent. range. They are made for alternating and for direct current readings, and in some cases are arranged with vertical dials, though this, necessitating a worm gearing, is not so simple as the direct rotating vanes.

London Electric Railway.—The convenience of the City and South London Electric Railway seems to be put beyond a doubt, paradoxical as it may seem, by its inconvenience. Complaints are often received of the trains being overcrowded, plainly showing that the convenience of the line is felt by more passengers than can always be accommodated. No wonder the other railways are being pushed forward with rapidity. With an economical construction in the first place, and a rush for places in the second, which must be met by quicker and quicker services, it seems probable that underground electric traction will convince company promoters of its advantages before the overhead electric tramway has had much more than a chance to show its capabilities.

Durban.—The contract open for tender for the supply of electric light to the town of Durban, Natal, will be a good chance for the introduction of larger business in South Africa, and as such is worthy of careful attention. The conditions of tender are plain and straightforward, though, unfortunately, there does not appear to have been an attempt to give the exact requirements in an engineering specification previously determined upon, usually the best and most satisfactory way of obtaining tenders. The Council is prepared to grant rights for supply of current at prices to be named by the contractors, and the town will also pay an annual sum for the public lighting, the amount of subsidy to be stated by tenderers. The town is not large—24,000—of which half only are white people. The tenders must reach the town clerk, Durban, by April 30.

Electric Light for Chester.— A deputation of Chester Town Council, consisting of Alderman Gilbert, Councillor Stevenson, and the city surveyor (Mr. J. M. Jones), having inspected the central electric stations at Brighton, St. Pancras, Eastbourne, and Brompton, have reported to the Watch Committee, who recommend the Council "to vote a sum not exceeding £20,000 for carrying out the recommendations of the deputation, and to refer the report to this committee, with power to take such measures as in their judgment may be proper for giving effect to such recommendations, and to adopt and carry out such arrangements as may in their opinion be necessary or desirable in carrying out the electric lighting order of 1890, the scheme and estimates, when prepared, to be submitted to the Council before a contract for providing an installation is entered into."

Mutual Telephone Company. — The first annua gathering of the employés of the Mutual Telephone Company was held at the offices, Portland-street, Manchester, on January 8. Mr. A. R. Bennett, M.I.E.E., general manager, presided, and there was a large attendance. In the course of a short address, Mr. Bennett said they had 900 subscribers already connected; the number of messages per week was nearly 30,000, and the length of wire, if put end to end, would reach half-way between Manchester and New York. It was intended to connect the exchange with Bolton, Liverpool, and other towns in Lancashire, and they had up to the present reached forward as far as Farnworth. The success of their efforts was due in a large measure to the excellence of the staff, which had been specially recruited from all parts of the United Kingdom. The evening finished with music.

Wallasey (Cheshire).—At the monthly meeting of the Local Board of Wallasey, held last Friday, the minutes of the Gas and Water Committee were brought forward, recommending that Mr. A. B. Holmes, Liverpool, should be engaged to make a report as to the practicability and cost of lighting the district with electricity, and also as to how far the proposed new gas works can be utilised for both gas and electrical works. Mr. Heap said it was desirable that the public should know that every effort would be made to obtain all the information that was required on the question of electric lighting, and with which to guide the Board with regard to their action in extending the gas

ANTHONY RECKENZAUN.

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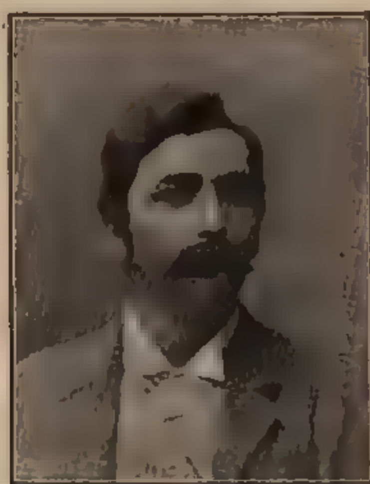

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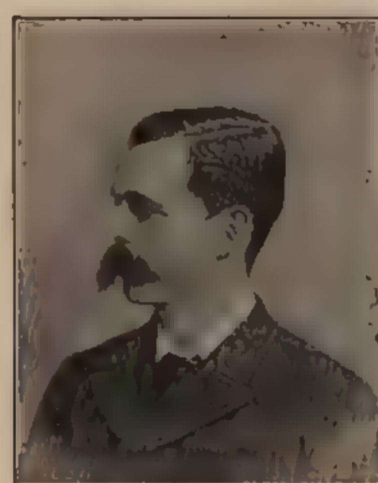


J. E. H. GORDON.

works. Mr. Hawkins remarked it was hardly a question of providing the whole parish with the electric light, but more in the way of introducing a supplementary light supply which would perhaps save the proposed extension. The proceedings were confirmed.

Abergavenny.—Electric lighting is sometimes used as a stalking horse for forcing the gas companies to reduce their rates. Whether this is the case at Abergavenny with reference to the County Asylum, or whether there is a distinct intention to use the electric light, does not appear; but at the last Local Board meeting the Gas Committee reported the consideration of a letter from the asylum, asking for a reply to a request for reduction of the price of gas to 2s. 9d. "before the asylum authorities decided as to the use of electric light." This veiled menace, however, did not produce the effect desired, and the Gas Committee, remarking the price paid by the asylum was only 2s. 11d., refused the reduction, and the chairman pointed out that the asylum was under contract to take gas or pay for a minimum quantity for another six years. Possibly the asylum authorities will now decide that all light above that minimum shall be supplied by electricity.

Large Ammeters.—In a recent issue we mentioned an ammeter constructed by the Weston Electrical Instrument Company, U.S., to measure up to 5,000 amperes as being the largest instrument yet made. Mr. James White, of Glasgow, maker of Sir William Thomson's measuring instruments, writes to point out that he is now supplying Thomson standard balances to measure up to 10,000 amperes. Besides this he has supplied Thomson ampere gauges to measure up to 6,000 amperes for use in electrolytic processes, and also for use with electric furnaces. It is interesting also to learn that he has recently submitted estimates to the Edison Illuminating Company, of New York, for two instruments to be used on the omnibus bars of their three-wire system, one of which is to measure up to 15,000 amperes and the other up to 100,000 amperes on each side of the neutral wire. It is evident, therefore, that we can claim the manufacture of the largest ammeters for Great Britain.

Frankfort Exhibition Finances.—At a meeting of the Managing Committee of the Frankfort Electrical Exhibition, held on December 28, 1891, Mr. Sonnemann, the president of the committee, submitted a preliminary report on the financial results of the exhibition. The total expenditure amounted to 1,362,000 marks, while the total receipts were 1,514,000 marks, showing a clear profit of 152,000 marks. It is proposed to dispose of this surplus in the following manner: Gratifications and salaries to officials still employed; publication of the official report on the exhibition and of the report of the testing commission; a bonus of 15 per cent., previously stipulated by contract, to Herr Oscar von Miller, to whose efforts the success is partly due; repayment of the grant of 50,000 marks made by the municipality of Frankfort and of the grants made by the Frankfort Chamber of Commerce and two private persons; and, finally, repayment of part of the payments made by exhibitors for hire of space and supply of motive power.

Cumberland.—The following from the *Carlisle Journal* speaks for itself: "Electric lighting does not make such rapid progress as might have been expected; but local authorities are doubtless holding their hands for a while until they can satisfy themselves as to the best method to adopt and feel assured about the cost. If we except the experiments in public lighting at Cockermouth, Keswick has led the way in providing the public with the means of supplying themselves with the electric light; but other towns are on the look out. Whitehaven is pondering over the subject, and at the last meeting of the trustees an offer of a London firm to take over the provisional order granted to the Board for electric lighting purposes was under consideration. At the meeting of the Workington Town Council a committee was appointed to make enquiries and report to the Gas Committee upon the feasibility of introducing the electric light for street lighting at Workington. Whatever the result of the enquiries of the committee should be it is evidently not expected that the gas works will be materially affected, because at the same meeting sanction was given to a loan of £545 for gas extensions."

Coast Communication. — The discussion as to electric communication with lighthouses and lightships is continued in the *Times* this week by a letter from Mr. R. S. Culley, who, with reference to the experiments on board the "Sunk" lightship, says that on enquiry he finds that this ship was chosen because of its sheltered position, yet the telegraph frequently broke down, and the experiment was abandoned nearly three years ago. In this case the ship's mooring chain was made to form a flexible tube, which did not, however, prevent chafing. Mr. Edward Stallibrass, A.M.I.C.E., writing from 25, Great George-street, says he has no hesitation in saying that should the money be forthcoming for the most important work of establishing communication with our isolated rock lighthouses, there would be no lack of engineers competent to successfully utilise it. But one attempt has been made up to now, but because that was a failure we need not assume the thing is impossible. He advises the laying down of three or four cables, securing each separately, and bringing them to one main cable at the first favourable spot above the rocks. It is unlikely all would be broken at once. The main cable would be no more likely to break than other submarine cables.

Automatic Transformer Switches.—The need for some method of reducing the waste in current in alternating-current distributing systems, caused by the absorption of magnetising current in the transformer, has long suggested itself to electrical engineers working with the high-tension current. Mr. Ferranti has just constructed an ingenious piece of apparatus for this purpose, which is found to answer well. For a large building, the transformer sufficient for maximum supply, say, for instance, 25-h.p. transformer, is surmounted by a smaller one, say, 2½ h.p. The circuits are led to a double-pole tipping automatic switch, which when pulled over puts in the larger transformer. The low-tension lamp circuit is brought down and connected to contacts which float in a bath of oil — two plates being arranged to be of the same polarity. Their repulsion is balanced by the tension of a long spring until it rises sufficiently, when the repulsion is made to actuate a magnetic contact. The current is shunted, and pulls over the switch, putting in the larger transformer. The reverse action takes place when the lights are turned out, the day supply being furnished by the smaller transformer. Some of these devices have been already supplied for central station use.

Tamworth.—Very few towns in England pay for their public gas lighting at the rate of 5s. per 1,000 cubic feet. Yet this is the rate charged at Tamworth, and it is therefore not very surprising that enquiries are being made with reference to electric lighting. Mr. Henry J. Clarson, C.E., in his annual report says that one of the most important matters which will be brought before the Council during the ensuing year will be this question of lighting the borough by electricity. He states: "The Corporation is now paying nearly £300 per annum for lighting the public lamps, the gas being charged at the rate of 5s. per

thousand cubic feet, less 10 per cent. allowed for cash discount, and at the same time another large consumer is charged at the rate of 3s. 9d. per thousand. This is an injustice which no longer should be tolerated, especially when it is known there are towns similarly situated to Tamworth at the present time supplied with gas at half the price; and there are also other towns lighted with electricity under similar conditions to those that would be required for Tamworth, where the electricity is satisfactorily supplied and sold profitably at a price equal to gas at 3s. 6d. per thousand cubic feet." From the above it will be seen that electrical engineers would have an ardent advocate in the Tamworth borough surveyor.

Junior Engineering Society.—At the next meeting of this society, to be held on Friday, January 15, at the Westminster Palace Hotel, Victoria-street, the chair being taken at 8 p.m. by Mr. Sidney Boulding, M.I.M.E., a paper will be read on "Modern Applications of Electricity to Metallurgy" by Mr. George C. V. Holmes, sec. I.N.A., hon. member. The paper will deal with the refining of copper; electrolysis of sulphate of copper solution with an insoluble anode; electrolysis of sulphate of copper solution with a pure copper anode, and the resulting deposition of pure copper on the cathode; electrolysis of sulphate of copper solution with an impure copper anode; how the impurities are got rid of during the process so as to allow of pure copper being deposited on the cathode. A description and details of cost of the electrolytic methods adopted in practice for refining copper will also be given. The paper will also deal with the manufacture of finished copper articles during the process of refining, and how the metal can be deposited in a dense and tough form. Elmore's system of burnishing during deposition will be described, and its advantages pointed out. Finally, the manufacture and cost by this process of tubes, rollers, hydraulic rams, sheet copper, wire, and tape for electric lighting will be gone into. The paper promises to be interesting and useful.

Cambridge.—An enquiry has been held at Cambridge by the Local Government Board into the application to borrow money for purposes of electric lighting. It was proposed to borrow £35,000. Prof. Garnett gave details stating they intended to use the Parsons steam turbine, driving alternators at 2,000 volts. He expected the actual cost to be £24,300, but he recommended the larger sum in view of extension of mains. The Master of Peterhouse spoke in opposition to the scheme, thinking a separate company would be best. He thought, however, that if the application were granted, opportunity should be given to consider whether direct current would not be best to adopt. Prof. Ewing, in reference to this, said it appeared from figures published by the companies that the consumption of coal for continuous was not much more than half that required for the alternate-current system. Prof. Garnett admitted that for the compulsory area with a proper supply, the continuous current might be cheaper, but thought on the whole alternate currents would be best. Alderman Balls, chairman of the Gas Committee, referred to the scheme as an unlimited company using the money of the ratepayers. He would prefer to see a private company, strongly objecting to the money of that town being used for speculating. The enquiry was concluded, though, of course, the result is not known.

Animal Electricity.—The series of lectures given by Prof. M'Kendrick, at the Royal Institution, on "Life in Motion," came to a close on Saturday. Though not trenching on the domains of practical electrical work, investigations into the electrical action of the living body, such as brought forward by these lectures, have not only immediate scientific interest, but may possibly lead to useful results in modifying our knowledge and use of condensers, and in stimulating the search for a means of economic generation of electricity by direct consumption of carbon. That there was in reality a distinct electrical action of the human body, Prof. M'Kendrick seemed to take as proved, and showed the effect of animal electrical currents by means of a very sensitive galvanometer. Current from animals such as the torpedo fish had long been known, but it was much disputed whether there was such a thing as an electric current from man. This man-current he demonstrated by putting his hands into a three-quarter per cent. solution of common salt contained in two flat vulcanite dishes. The effect upon the galvanometer was greater as the number of fingers inserted was increased, and was greatest when the muscles of the arm were contracted. There were no fewer than 50 species of animal that were living electric batteries, though only five or six were generally known. In concluding the lecture, he warned his hearers not to suppose that the final settlement of these questions had been reached. Many problems awaited solution, and he urged that everyone should keep an open mind for the reception of the truth, from whatever quarter it might come. The lecture and the experiments were heartily applauded by a large audience, which included the Lord Chancellor, Sir F. Bramwell, and a number of well-known scientific men.

Walsall.—At the meeting of the Walsall Town Council on Monday the recommendations of the General Purposes Committee, with reference to electric lighting and traction, came before the Council. These recommendations were, that the Council provide an electric lighting plant on the lines suggested in the report of Mr. F. Brown, A.I.E.E., at an estimated cost of £21,450, and that the common seal be affixed to an agreement with the South Staffordshire Tramways Company for the erection of iron poles in the public streets for the working of the lines of tramways within the borough by means of overhead wires. With regard to the electrical scheme, the Mayor said Mr. Brown's estimate was that, supposing 2,000 lights, of 16 candles each, were taken, there would be a profit of £1,266 a year. That result might not be attained, but at all events there would be a great improvement in lighting, and they had sufficient reason to believe that 2,000 lights would be taken. In Birmingham light could not be produced sufficiently fast to meet the demands of customers, and he thought the authorities of the city had made a mistake in not taking the electric lighting into their own hands. The area, he explained, in answer to questions, included the streets in the centre of the town, and the scheme would eventually be extended to the whole of the borough. Alderman Lindop, as a member of the committee, added that he should do his best to get the scheme ready in six or eight months—certainly for next winter. As to the agreement with the tramways company, the town clerk and the mayor explained that the feeder wires, except in cases where special permission was given, would all be underground, and the trolley wires overhead. Every seven years the Council would be entitled to revise the agreement with the company. The cars would be much improved. The right had been reserved for the use of the poles for electrical or gas lamps, and the use of the poles for advertising was absolutely prohibited.

Steam or Electricity for Tramways.—The incursion of the electric tramway at Leeds has roused up the tramway companies of the North, and some pretty little discussions are likely to result, from which we hope electricity will come out victorious. The subject has been

taken up by Mr. Vaux, manager of the Bradford Tramway Company, who is evidently willing to be converted by advocates of electricity, but is not yet converted. The question is not between horses and electricity, or even between cable and electricity, with Mr. Vaux, but with electricity as against steam—steam meaning in his case compound tramway engines. He does not refer to the convenience or cleanliness, questions in which the public are more interested than the company perhaps; but discusses simply the item of cost of hauling and management. The engine most suitable for tramway work, according to the experience of the manager of the Bradford tramways, is one approaching the good engine with surface condensers. The Bradford company have now seven such engines, which show a saving of 25 to 33 per cent. over other engines. The following figures are given: The engine was twice the weight of the car it had to carry; the weight of the rails had been increased from 50lb. per yard to 106lb. per yard, the best form being girder rails laid in concrete 6in. to 9in. thick. The tramway engines have a tractive force of 4,536lb. on the drawbar, and were calculated to haul 17 tons up an incline 1 in 17, or 112 tons on the level. The cost of the Bradford tramways is 9·38d. per mile, including running, management, and maintenance. With reference to electricity, Mr. Vaux remarks that it had been stated that electricity would save 3d. a mile, but he scarcely saw how it was possible. The mere cost of hauling at Bradford was only 4½d., and a saving of 3d. would leave only 1½d. a mile, barely sufficient to pay men. Repairs, he thought, would be increased, and possible rent and cost of licenses. He failed to see how an economy can be effected. It will be for electrical engineers with these details before them to convince Mr. Vaux to the contrary. The item of 4½d. is low, much lower than usually taken as the cost of steam hauling, but it seems probable that depreciation, a heavy item in steam tramways, is not therein taken into account.

Inverness.—At a meeting of the Police Commissioners in committee on Jan. 6th, a report by two engineers on the practicability of introducing the electric light into Inverness was discussed in connection with a proposal to extend the gas works at a cost of £10,000. The report described a number of schemes for obtaining water power for turbines, and recommended one whereby the necessary power could be got from the Caledonian Canal at the Muirtown Locks, Inverness. The report stated that "on the Muirtown or north side of the canal a working fall of 28ft. can be arranged from the top of the locks to the basin, according to designs which we have sketched and estimated for. This fall gives 200 h.p. with a discharge of 4,722 cubic feet of water per minute, 600 h.p. with a discharge of 14,240 cubic feet, and 1,108 h.p. with a discharge of 26,180 cubic feet. A supply for 600 h.p. would cause an average velocity of less than one-seventh part of a mile per hour in the canal, and for 1,108 h.p. an average velocity of one-fourth of a mile per hour, the central surface velocity being slightly more. For this place we have designed an arrangement for turbines, each yielding 260 h.p. when using 6,140 cubic feet of water each per minute; or, with both at work, 520 h.p. with 12,280 cubic feet of water per minute. The cost of the two turbines complete, with the necessary shafting, pulleys, governors, sluice gates, and grating, erected and ready for belting on to the dynamos, would be about £1,550. The lead, tail race, and by-wash would cost about £3,050, and the turbine and dynamo house with foundations for four dynamos and space and foundations for two engines if required, and with tail race underneath and with lead, about £1,400. The by-wash and sluice gates required at Dochgarroch Locks would cost about £1,080, and an overflow for the canal basin about £120. This makes the total cost of the complete works and turbines for 520 h.p., £7,200. The cost of a smaller or greater power of the same design can be given if required. The electric cable can be taken across under the canal at the end of the stone invert below the swing bridge." It is understood that this scheme is the one that would best suit the Canal Commissioners, because the discharge from the turbines could be used for raising the level of the canal basin when required for deeply-loaded ships, for which the normal depth of the basin is not sufficient. Along with this scheme a fall of 16ft., with the same amount of water, might be worked from the overflow of the canal basin at the end of the sea embankment. With the discharge of 12,280 cubic feet per minute it would yield 297 h.p. It was resolved to have the report printed before it is finally disposed of, and in the meantime it was agreed to recommend that, whatever may be done with the electric light, it is essential to extend the gas works.

Annual Dinner.—On Saturday last the dynamo department of Messrs. Johnson and Phillips held their second annual dinner at East Greenwich. The dinner was highly successful, over 80 sitting down to a substantial repast, under the presidency of Mr. S. Sudworth, chief foreman of the dynamo department, who was ably seconded by Mr. Chennery, foreman of the engineering department, and Mr. Lawrence, of the submarine department. There were also a number of engineers of other firms present—Mr. Jones, engineer to Messrs. Drake and Gorham; Mr. Miller, electrical engineer to the Bank of Australasia; Mr. A. J. Upton, engineer to the Union Bank of London; Mr. J. N. Cooper, of the Edison-Swan Company; Mr. Evered, electrical engineer at St. Pancras, and others. Mr. Sudworth, in giving the health of the firm of Messrs. Johnson and Phillips, said that the business was going up by leaps and bounds. Their dynamos were growing larger, while more of them were turned out, and the manufacture of the D.P. accumulator, he thought, promised to become almost more important than that of dynamos. The firm's products now went throughout the globe, and in Africa, China, as well as the European nations, the dynamos and lamps made by the men then at dinner were used for electric light. He paid a great tribute to the kind and considerate way in which the firm treated their men. No one, he thought, could ever wish to be better treated than they were. Every consideration was shown for their comfort and intellectual aid, as the beautiful library lately established served to show. The toast was responded to by Mr. Chennery, who was evidently, from his reception, as much liked for his good nature as respected for his good discipline. "Harmony between men and employés" was his watchword. The health of Mr. Gisbert Kapp was proposed by Mr. Evered (lately with Messrs. Johnson and Phillips, but now in charge of the Kapp machines at the St. Pancras central station) in very sympathetic language. He had worked for many years under Mr. Kapp, who remained to workmen as well as others the same kindly, courteous gentleman he always had been. Mr. Pierce also spoke in answer to enthusiastic calls. Mr. Lawrence, as the oldest employé, and at one time timekeeper and only foreman, spoke of the growth of the works, and hoped they would all long continue in the same firm. The evening was finished in fine style with songs, of which those with a fine rousing chorus were best appreciated. Mr. William Davis, who acted as pianist, was to be complimented on his performance. The general good feeling and enthusiasm seems to augur well for Messrs. Johnson and Phillips, and the men will doubtless look forward to many equally successful dinners

THE CRYSTAL PALACE EXHIBITION.

"Will the Exhibition be a success?" was the question asked by a gentleman upon getting out of the train at the Palace on the opening day. Such a question, too, will often be asked during the next few months, and to it time alone can give a definite answer.

The Exhibition was opened without ceremony on Saturday, but we understand that in about another week there will be a formal visit of inspection, and possibly some specifying. It is expected by that time the laggards in love—no, in preparation will have put in their time, completed their exhibits, be ready for giving information and for receiving congratulations, and—orders.

The first edition of an exhibition **catalogue** is rarely complete, and we should perhaps defer our remarks, but an excellent plan has been followed in preparing a series of short essays of a popular character to introduce the separate departments to the visitor. This work has been left in the able hands of Mr. H. J. Dowsing, who undoubtedly must have felt himself heavily handicapped in attempting to cram a mass of interesting information into the small space of two or three pages. We believe the general public will rightly appreciate this endeavour to give them trustworthy information in a simple manner.

The backwardness of many of the exhibits, and especially those in the machinery department, makes it difficult to adopt what by many would be thought the best method to describe the exhibits. The scheme we propose to adopt, however, will need little or no alteration. It will be admitted at once by experts that there will necessarily be comparatively little that is new from a technologist's point of view. It will be also admitted that the main object of an exhibit is to let the world of visitors and the world of readers learn the specialities of the exhibitor's manufacture. The technical journal, then, should, in our estimation, become rather more of a go-between from the exhibitor to the general public—the ultimate buyer—than from the technologist to the technologist.

When and how to begin is the difficult point to decide. However, as every eye will nightly be turned towards the brilliant screen of incandescent lamps exhibited by the Edison-Swan Company at the end of the North Nave, let us turn thitherward. At the time of writing the screen is incomplete, but sufficient lamps are wired thereon to show what a gorgeous flood of light there will be when fully complete. Underneath the screen is the stand of the company, which contains a fine assortment of the manufactures of the company. When finished we will visit it again. Next, in the centre of the nave, is the large, varied, and excellent display of the Post Office. Here we have the historic apparatus of telegraphy on four long counters. A day—nay, a week—might be spent around these exhibits in tracing the gradual development of telegraphy, as telegraphy is understanded of the people who do not usually place telephony under the same ægis. But telephony, as we shall see by-and-by is well represented further along. The extreme points in the telegraphic display of the Post Office are to be seen in the various (1837) instruments of Cook and Wheatstone, in the first of which five needles and five line wires were required, and the other extreme in the beautiful multiplex apparatus of to-day, by means of which half-a-dozen messages, or rather half-a-dozen instruments, are in communication with only one line wire. Men who are approaching the age of threescore years and ten can, or ought, to well remember the introduction of telegraphy, and, of course, the astounding development of all things electrical since that time. Their starting point at this exhibition should be the Post Office exhibit, and then passing around the aisles and galleries of the Palace they would have presented to them an epitomised history of their lifetime so far as electrical developments are concerned. Commencing with telegraphy, what are the great departures? Electro-deposition was soon born, and now claims thousands of labourers. The electric light in the forties had a kind of will-o'-the-wisp existence. Its turn had not come, but men prophesied, and had no honour. In the beginning of the fifties came submarine work, and for many years claimed great attention, till, after herculean efforts, it was proved a success. Meanwhile, that will-o'-the-wisp would dance backwards and forwards, and throw a glamour over men's minds, but its time was not yet. The seventies were to inaugurate a new era—a new development of telegraphy—a development to enable us not only to convey signals but sounds of speech, was ushered in, and is now enjoying a flourishing manhood. And the electric light came also to stay. Gramme, Siemens, and Jablochkoff in 1878 paved the way. Then came a hurricane, and the 1881 Exhibition at Paris and the 1882 at the Crystal Palace took the world by storm. The success of electric light was demonstrated. Incessant activity gave us the Planté secondary battery and its successors. Inventors followed Gramme and Siemens by the hundred, and through the eighties we have witnessed a feverish excitement which is carrying electrical matters forward by leaps and bounds. This is but a slight indication of what the old man might think in his wanderings among the stands. But we must be more precise. Opposite the Post Office exhibit is stand No. 147, belonging to **The Mining and General Electric Lamp Co.,** a representation of which our artist has enabled us to produce. This company appeals to us metaphorically for consideration. Previous to a visit to the 1881 Paris Exhibition, Mr. Desmond FitzGerald had shown us experiments he was making and investigations he was carrying on to attempt to make more perfect secondary batteries than were public

Lithanode Electric Mining Lamp.

property at that time. We reminded Mr. FitzGerald that he and others had worked in this direction as far back as 1863. While at Paris a conversation with Mr. Crompton ended in a promise to bring him into communication with Mr. Desmond FitzGerald. Subsequently they met, but afterwards drifted apart—Mr. Crompton to develop his business into the gigantic concern it has become, Mr. FitzGerald to the laboratory to perfect his "lithanode," the name he has given to the material he uses in his secondary battery. After many vicissitudes the Mining and General Company was formed to exploit Mr. FitzGerald's, Prof. Frankland's, and other methods of manufacturing secondary batteries, and to carry on the business of electrical engineering generally. For some time there was lacking a good business head, but it seems these difficulties are being surmounted, and under the energetic and capable management of Mr. J. T. Niblett the company is rapidly assuming its right position, and placing its specialities on the market. The stand comprises a dark room, wherein to show more effectively the capabilities of the small hand lamps and miner's lamps, in which direction particular attention is being given. Mr. N. Story-Maskelyne, M.P., as many of our readers know, has paid great attention to all that concerns the safety of miners, and no doubt it is due to his initiative that the company of which he is the chairman should specially examine into the merits of secondary batteries for lighting purposes in mines. Thus we find, as we should naturally expect, the company's

exhibit comprises, among other things, a good display of the metal-cased safety electric hand lamp, which has been specially constructed for use in such places as coal mines. In designing it every precaution has been taken to ensure perfect reliability. It will be found to withstand without injury all ordinary usage and the accidental rough treatment incidental to employment in coal mines. The lamp consists of a small two-cell battery of the lithanode type, mounted in an outer steel protecting case. A circular switch serves to throw the lamp in and out of action. Insulating charging terminals are placed above the lantern bezel, and these are covered by projecting lugs attached to the cover, so that when the lamp is in action the cells cannot be short-circuited, and therefore all possibility of sparking is avoided. When the lamp is used in coal mines the bezel carrying the glass glow-lamp protector may be secured against removal by means of a lead locking-pin. The ordinary full-size lamp weighs about 4¼lb., and when fully charged it will run a 1-c.p. glow lamp for a period of 12 hours. The actual cost of the electrical energy consumed is about one-tenth of a penny per shift of 12 hours. The company's miner's lamps have now withstood the test of time, and from the very satisfactory manner in which they have passed through some most severe practical trials they may be relied upon to fulfil all the requirements of a nearly perfect electric safety hand lamp. This lamp is known in France, where it is much appreciated, as the "Stella" safety lamp. Other forms of miners' lamps are also shown. Lithanode batteries of a portable nature, and mounted in fancy wood cases, are to be seen. Some of these are adapted for use in gas works, petroleum ships, gunpowder mills, and similar places where an absolutely safe illuminant is required. Four, six, eight, and ten-cell batteries, suitable for carriage lighting, or domestic requirements, are shown in action. A case containing electrical measuring instruments, automatic cut-outs, hydrometers, and other secondary battery accessories may be seen. Batteries for house lighting, traction purposes, military and naval use, medical and dental purposes, are also shown. Some specially constructed cells useful for actuating telegraphs and telephones are to be seen. Some of the batteries have been under trial at the General Post Office, and are giving every satisfaction. A variety of lithanode-zinc cells are shown. This combination gives the highest known E.M.F. of any practical cell.

To other exhibits of the company we shall refer in another issue.

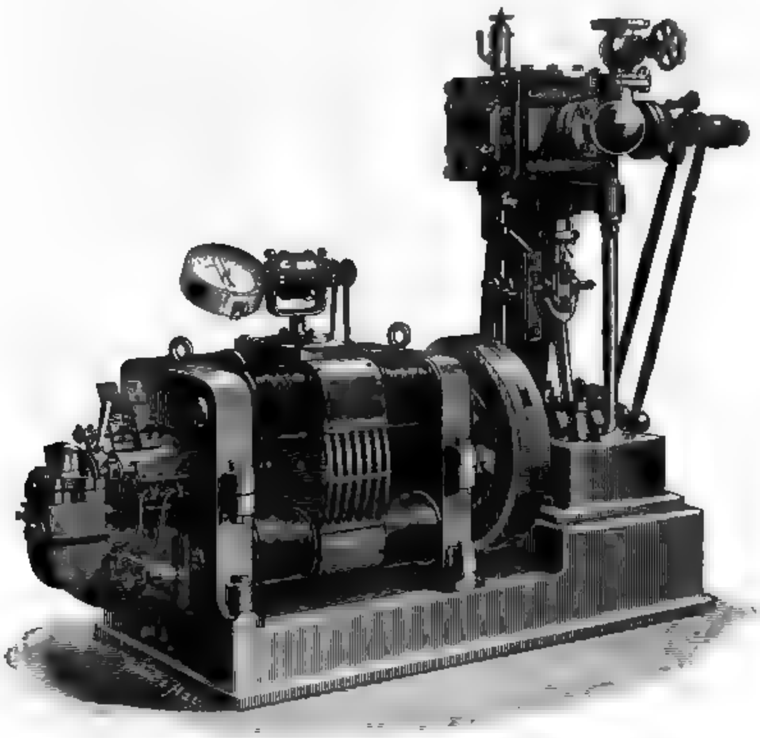
A little further down the nave we come to one of the most prominent exhibits, that of the **Fowler-Waring Cable Company,** and it had the almost unique peculiarity of being quite ready on the opening day. This stand, No. 90, which we illustrate on next page, is devoted to wires, which, like the rats of the poem, are of all kinds, from the smallest to the largest in common use. Here we find concentric wires, lead-covered wires, armoured wires, wires and cables for electric lighting, and for telegraph and telephone work. A pyramid 26ft. high is formed of lengths which have been cut from representative cables manufactured at their North Woolwich works for our own Government, for the French Ministry of Posts and Telegraphs, and for the Government of Queensland. There are also specimens of the cables used for connecting the London telephonic centres to the Paris telephone cable; and among the more important electric lighting cables are sections of the high-tension distributing mains which are employed extensively by the London Electric Supply Corporation. A large number of cable joints, jointing tools, and junction-boxes are also exhibited, together with the diplomas and medals which had been awarded to the company.

It is perhaps a little invidious until all are complete to indicate any one exhibit as the best, but we certainly feel inclined to mention that of the **Brush Electrical Engineering Company** as one of the most important and imposing of the whole Exhibition. Their exhibits are divided into two—one in the Main Transept, and the other in the Machinery Hall. The one includes what is termed stationary exhibits, and the other moving machinery, though, in fact, much of the former will be driven by electric transmission of power from the Machinery Room and shown in motion. Standing in the centre of the transept, just opposite the entrance to the Palace from the railway station, the Brush Company could hardly wish for a better position for the exhibition of the products—dynamos, arc lights, motors, tramcars—and the very handsome manner in which they have been mounted serve the better to show them off; while in the Machinery Room the fact that the Brush Company can label their machines "exactly the same as used for lighting the City of London" will cause the attention of private persons, engineers, and members of local authorities to be turned with great interest upon their

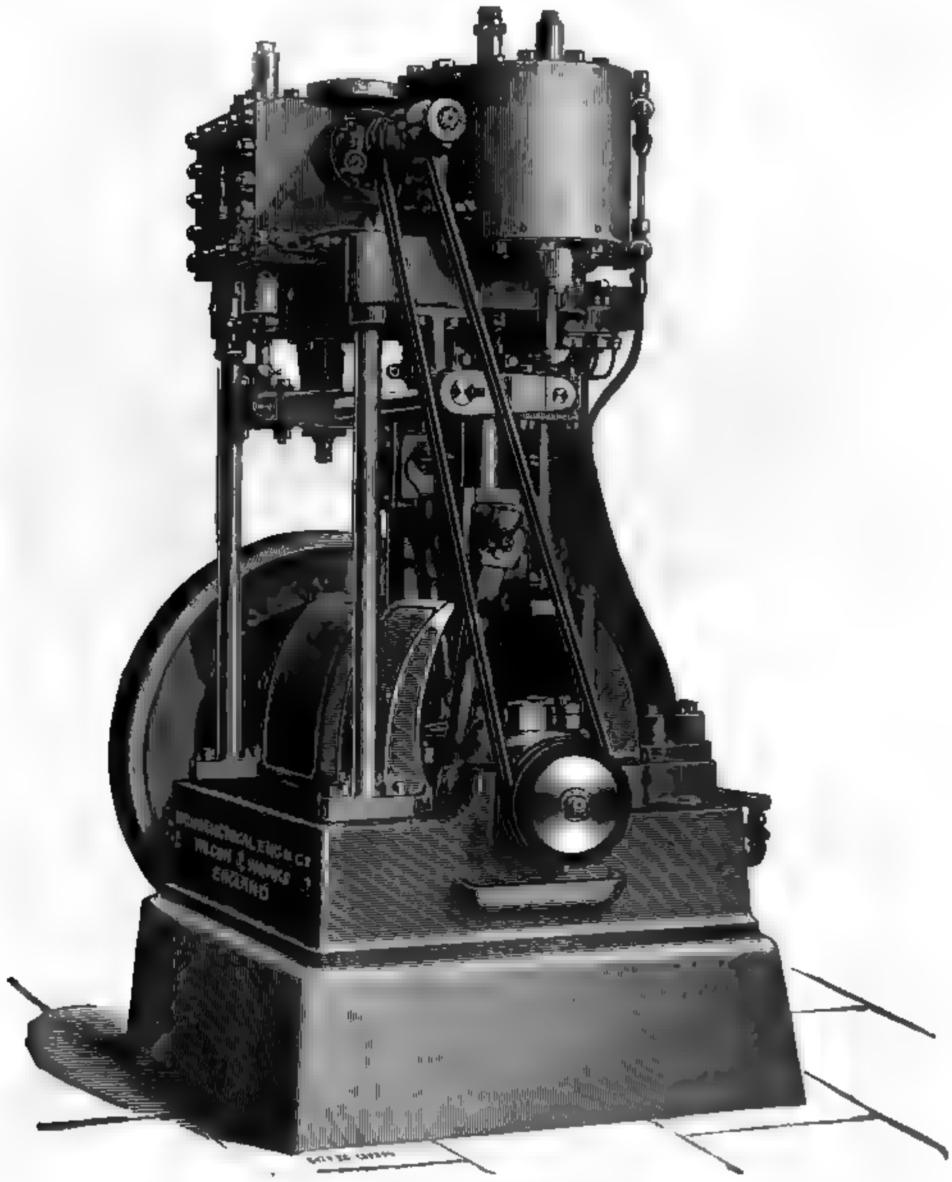
exhibit. This Brush exhibit in the Machinery Room will certainly be a fine sight when all is in working order, and additional interest is given by the fact that all the plant—engine, dynamo, and fittings—were made by the company either at their works in Lambeth or at Loughborough. There are five sets of engines and dynamos, ranging from the large size used at the City of London Electric Light Company's station at Bankside, down to the natty little combined plant of 10 h.p. to light a private house—and even smaller sizes still of combined plant are shown in their stationary exhibit. We give an illustration of the specially designed Raworth engines, made by the Brush Company at their Falcon Works, and used either for driving by belting or for driving direct by "Raworth" flexible coupling. The first exhibit is the central station plant above mentioned, as used for the City lighting. This comprises a vertical engine of 280 i.h.p., driving a Mordey alternate-current dynamo, giving 100,000 watts (100 units), capable of supplying 3,000 to 4,000 8-c.p. lamps. The following are the particulars of the engine: high-pressure, compound, working at 140lb. pressure, cylinders 15in. and 25in. by 16in. stroke, running at 168 revolutions a minute. This engine drives the alternator by means of an endless rope gearing, running in eight grooves and over a "jockey" pulley. This dynamo is not the largest the Brush Company make, the largest at present made being of 200 units capacity, or double the capacity of the one shown. The current from this dynamo will be led from the Machinery Hall to a similar alternator at the other stand. This second Mordey alternator will be run as a motor, demonstrating the utility and efficiency of these machines for the electric transmission of power, either for the utilisation of water power to light a town from a distance, or for driving a factory engine or such purpose.

The second engine and dynamo shown by the Brush Company is only of 75 i.h.p., driving one of the famous Brush arc light dynamos. The details of the engine are these: cylinders 9in. and 15in. by 10in. stroke, 217 revolutions, 140lb. steam pressure. The dynamo is one of the "8 L" type, capable of supplying current for 55 Brush arc lamps in series for town lighting. This dynamo is also driven by endless rope gearing with eight grooved pulleys, the rope passing over a jockey pulley for tightening. The dynamo will not work at its full load, at any rate at present. The current will be led to the six lamps on the Brush Company's masthead light in the centre of the transept, and will also supply lamps at each corner, on the specimen City lamppost, and four or five in the Machinery Hall. The third set of machinery is a 50-i.h.p. vertical engine, driving one of the Brush Company's Victoria incandescent dynamos. The engine has cylinders of 7½in. and 13½in. by 8in. stroke, working at 250 revolutions. The dynamo is such as used generally for lighting institutions or large private mansions, and is of a capacity of 36,000 watts—equal to about 1,000 8-c.p. incandescent lamps. The fourth set is particularly interesting to intending purchasers of electric lighting apparatus, being a combined plant in which the Raworth vertical engine is connected direct to the Victoria incandescent dynamo by means of Raworth's patent flexible friction grip coupling, mounted upon a combined bed-plate. These sets of combined engine and dynamo make exceedingly compact and useful electric light plants, and are much used for shiplighting and other places where the question of space is one of importance. The engine in this case is of 16 i.h.p., single cylinder, size 8in. by 6in. stroke, driving an 18-unit dynamo. We give an illustration of this set. A sensitive governor is driven from the engine shaft, and above the dynamo is mounted a tachometer, or speed indicator, driven from the dynamo shaft. A fifth exhibit, comprising another combined plant of 10-i.h.p. engine, coupled by flexible coupling to a small Victoria incandescent dynamo, is used to supply the current for exciting the field magnets of the large alternator.

Returning now to the Main Transept, we will mention what the Brush Company show here; but we intend later on to refer again to these more in detail. In the first place, an enormous mast lamppost, built up of tubular plates, will be sure to



Brush Company's Combined Plant. Victoria Dynamo and Vertical Engine.



The Brush Company's Vertical Engine.

attract attention, reaching as it does nearly to the height of the roof of the Palace, and carrying six arc lamps. A specimen lamppost, as used in the City, will shed light upon the stall, while at each corner other Brush lamps will be lighted. In the centre of the stand is a beautiful specimen of tramcar, to be used for electric traction, made at the company's

Falcon Works, Loughborough. In the front of the stall is a 50-unit Mordey alternator. This we have already mentioned as intended to be shown running as a motor. Down one side of the stand are a series of combined plants of engine and dynamo, of 6 h.p., 10 h.p., 16 h.p., and 30 h.p., for house and shiplighting. These will be shown in motion, the dynamos acting as motors. On the other side is an equally interesting set of Brush arc light dynamos for 2, 4, 10, 16, 25, and 55 lights each. In the centre is an enormous Blackman air-propeller, as used for ventilating mines or breweries, or for forced draught. An important exhibit is also that of a 24-h.p. electric motor driving a quartz crusher for mining purposes. The crusher is made by the Sandy Croft Foundry and Engine Company, of Chester, the motor being one of the Brush Company's Victoria machines. We must not forget to mention also that in front of the exhibit we see a pyramid of the Brush Company's transformers used for town lighting on the alternate-current system. In this company's exhibits we thus find almost the whole range of electrical engineering covered. From small installations of two arc lights, or 20 incandescents, up to the large engines and dynamos, with their switchboards and lamps, used for central supply stations for town lighting, sets of electric light plant for ships, ventilating fans, transmission of power for mines, for quartz crushing, for electric tramcars, the lighting of docks, of city streets, projectors for naval and military use, dynamos for colliery lighting, motors for hauling are all shown; and when it is remembered that the company not only supply but have manufactured the whole of the machinery they now exhibit, the commanding position of the Brush Electrical Engineering Company can be thoroughly appreciated.

The exhibits of **Messrs. Crompton and Co., Limited,** are conspicuous all through the Palace. At one stand we see a projector ready to throw its vivid rays in a stream of light wherever directed, while all around are dynamos made by this company. A little further down is a large crane worked electrically, and it is this item of their exhibit we choose for description in this issue. The crane shown is the original model made in the early part of 1888, and is claimed to be the first one constructed in this country. It was the outcome of a large number of experiments, and the cranes that have been turned out by the firm since the above date have been made on the same principle, and have in every case worked very satisfactorily. The first crane made by Messrs. Crompton was supplied to Mr. Hermann, of Dodd-street, Limehouse, for work in a timber-yard, and is still employed there, having given every satisfaction. We believe it is a fact that Mr. Hermann's place has been burned down twice, and great difficulty was experienced in getting the insurance companies to cover it, and then only at the high rate of 25s. per cent. Immediately on the introduction of the electric crane, and the consequent abolition of a boiler needing fire, Mr. Hermann's premium was reduced to 12s. 6d. per cent., and this on an insurance of £40,000. The crane hoists, travels, and slews at the same time. The attendant having no fires to stoke, nor smoke to prevent him seeing what he is about, can perform his work with very much more ease than with a steam crane, and at a far more rapid rate. In Mr. Hermann's case a large dynamo is used for lighting the works, and leads are taken from this machine to run the crane—no extra attendance is therefore required for driving the generating machinery. In this connection we may mention that, owing to the satisfactory working of the crane at the above timber-yard, Messrs. Crompton have received orders not only for similar plant, but also for electric capstans and haulage plant generally. The crane shown at the Exhibition is driven by a five-unit motor taking 45 amperes and 110 volts. It will hoist, we understand, a weight of two tons, at the rate of 80ft. per second. The motor is connected by a friction wheel to an intermediate shaft, which is connected by a spur wheel to the drum-shaft. This latter contains a clutch to throw the drum in or out of gear. A powerful band brake is provided on the drum and is worked by a treadle. The slewing is done by intermediate gearing from the intermediate shaft, and is controlled by a hand lever conveniently placed. The crane is made to travel by the movement of a hand wheel in a manner similar to that by which the operation of slewing is carried out. It is fitted with Crompton's patent sight-feed lubricators, and all the latest improvements. Current is supplied to the crane by two rails, along which are laid copper strips. The rails are carried on Crompton insulators similar to those used in his underground mains, and are laid between the travelling rails. The current is taken off by an improved form of collector gearing with carbon brushes. A double-pole switch and fuse are interpolated in the circuit. The crane will be exhibited at work at certain stated times during the Exhibition, due notice of which will be given.

Crompton's Electric Crane.

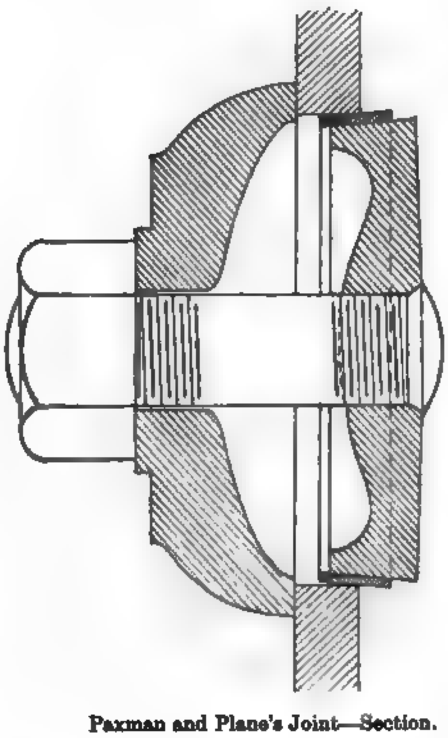
Close by is another early complete and excellent exhibit, Stand 173. This is the exhibit of the Western Electric Company, and, as we remarked last week, have a comprehensive exhibit covering the whole field of telephonic requirements, of which we hope to give full particulars in

the course of our review of the Exhibition. We select for illustration this week one of the smaller switchboards shown by them. It differs from their well-known Standard model in having no clearing-out drops, one of the subscriber's drops being left in circuit for clearing, as in a single-cord board.

It will, perhaps, be advisable to say little of the machinery department for the moment, except the boiler-room, which is practically complete. **Davey, Paxman, and Co.**

Western Electric Company's Telephone Switchboard.

reign here supreme, and, under the indefatigable activity of Mr. H. D. Wilkinson, this firm seems destined to add still further to the high esteem in which its productions are held. On the left-hand of the boiler-room is a battery of eight steel locomotive type boilers used for supplying steam for driving the engines during the Exhibition. The boilers contain about a total heating surface of 5,640 square feet; they are provided with steel fireboxes, and are made in the best known and most modern manner, being well stayed and tested by hydraulic pressure to 250lb. per square inch for a working pressure of 140lb. per square inch. A steel steam receiver runs the entire length of the boilers, connected to each by a separate stop-valve, so that either or any of the boilers can be shut off immediately if necessary. The object of the receiver is to give dry steam to the engines, and to turn back to the boilers any condensed steam. The pumps feeding the boilers are provided by Mr. A. G. Mumford, of Colchester, and the injectors are of Messrs. Gresham and Craven's manufacture. The boiler fittings are asbestos-packed, and the water-gauges are fitted with protecting shields. On the right is one of Paxman's patent new type water-tube boilers, in boiler-house, used for supplying steam for driving engines during the Exhibition. The boiler contains about 1,572 square feet of heating surface. This boiler is made on a new principle, in which it automatically separates any water in the steam. The joints are made on Paxman and Plane's patent metallic principle, and are a very great advance in this direction. This is the first time this boiler has been exhibited to the public. It contains several new features, principally as to the circulation and separation of steam from water. Furthermore, it is made in sections, which are very readily removable and are much more handy for repairs than is common to many of the types of these boilers. The joint for the headers for getting at the tubes are of Paxman and Plane's patent above referred to (see annexed sketch), a pattern of which can be seen at their stand. This is a very simple, but at the same time serviceable joint, and will, we expect, come into general use, not only in this type of boiler, but for manholes and mudholes, etc., in other kinds of boilers. The sketch shows the plan as being round, but the joint can be made any shape. The way to break the joint is by unscrewing the nut and pushing the small door inwards. The metallic ring is made of pliable metal, so that it is quite easy to spring and alter its shape to enable it to draw through the opening. After the ring has been removed, then, the door can be easily drawn through, as will be seen from the sketch that the door is smaller than the opening made in the plate. The hole is made conical or taper, with the largest taper on the inside, and the metallic ring is made precisely the same taper as the hole so as to fit the hole. The door is made with a slightly less taper, so that the joint is made on the outside edge of the door. The joint possesses the following advantages: It can be quickly broken and remade, and when made it is perfectly tight. The greater the pressure inside the tighter the joint, as the pressure assists in keeping the joint tight. It is very lasting, and the metallic cover is almost indestructible and will last for many years. It is very cheap and always reliable, and being so easily and readily made, as above described, it enables the boiler to be taken to pieces for examination with a minimum loss of time. This is an advantage not hereto obtained, and we believe this joint will become that of the future and have a great sale, as Davey, Paxman, and Co. are willing to grant licenses to all makers of tubular boilers. The other exhibits hereafter.



Paxman and Plane's Joint—Section.

THE

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 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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1892.

We have made some endeavours to gather opinions as to the most important points needing elucidation in central station work. Well, we have obtained opinions, but for practical use they can hardly be classified to advantage. Most electrical engineers with whom we are brought into contact have sufficient faith in their own powers to say, Give us the opportunity to instal a central station, and we will show that it can be done satisfactorily. In fact, we are more convinced than ever that there must be some diversity in practice, and that the system followed in one district with the best results may not be so suitable to another district. In the majority of cases the consensus of opinion is in favour of sub-stations. Though it might be thought otherwise, there seems to be a growing feeling in favour of accumulator sub-stations. No doubt the future will make several points clearer, and as regards systems of mains will show how far maintenance must enter into consideration in designing the original system. The survival of the fittest involves time, and as yet deterioration has played little or no part in our thoughts.

A not very inviting discussion has recently taken place relating to the "sheer" cost, whatever that may mean, of electrical energy. There are two views regarding cost put forward by controversialists, and both these views may be taken as correct. One side argues that the cost per unit of electrical energy generated is all important, contending that all other portions of the charge to the consumer are of the nature of constant charges, and fluctuate but little with the number of units supplied. Thus, if the charge to the consumer is 8d. per unit, the prime cost of the unit is 2d., and incidental charges 6d. Now it costs 6d. to distribute one unit, but it only costs 6d. to distribute one hundred units, so that with the increased demand for units the profits should increase according to the prime cost per unit, and not according to outcharge per unit. On the other hand, the consumer and the shareholder deride the future, and prefer a certain advantage in the present. They look simply at the balance-sheet, which shows a certain expenditure and a certain income. This expenditure has been increased by the production and the distribution of a certain number of units. According to these views, dividing the total expenditure by the number of units sold gives the prime cost per unit. As we say, both people are right. We are among those, however, who contend that the electrical engineer is not concerned with the consideration of the prime cost from the shareholders' point of view. His chief object is to keep the cost of generation at the lowest possible point, and to distribute to the consumers as great a percentage of the energy generated as possible. The other part of the business lies with the management. It will be seen, then, our view is that the engineer's responsibility ends at the house terminals, not at the dynamo terminals; and, if we mistake not, some engineers prefer to argue as if their responsibility

ended at the dynamo terminals. A misfortune in connection with cost is the persistent iteration of comparative figures of electricity *v.* gas. Many electrical engineers promise their customers or lead them to expect the electric light shall be maintained as cheaply as gas. It may be so in the millennium, but not now, unless there be a mental reservation as to the prices of gas meant. There is usually another reservation that, unlike gas—which the servants light and leave burning all the evening—the electric light is to be switched on and off just when and where wanted. We have pointed out again and again that if what the popular mind takes as meaning as "cheap as gas" is so in reality, electricity would really be about half the price. That is, if gas and its equivalent in electricity cost 4s., the real cost of the electricity to the consumer would be far less than the real cost of gas. There is no getting out of the fact that the indirect expenditure due to gas lighting often costs as much, if not more, than the gas itself, so that the cost of gas does not end with the payment of the gas bill. With the electric light it is different. The indirect payments are absent. And if these payments are not taken into consideration by business men, it is the fault of the exploiters of electric lighting.

THOS. BARRACLOUGH AND CO., LIMITED, Globe Works, Rochdale-road, Manchester, report a large and increasing amount of business during 1891 in the manufacture of their specialities. In the past year they had a larger turnover than in any preceding, and although they worked overtime the whole year, and for a portion of it worked day and night, they were not able to keep pace with the increasing demand for machinery. They have added materially to the number of their tools, and are now completing a new erecting shop with an additional 10-ton travelling crane, in order to facilitate the manufacture of heavy machines. Last year they completed the installation of the large submarine cable factory in Calais, consisting of six machines for making deep-sea cables, one machine for making intermediate cables, and one machine for making shore-end cables of the heaviest description. The two latter machines are each driven by a pair of independent steam engines. In addition to this they made the whole of the core-serving and accessory machinery. The company is now engaged in executing a large order for a new submarine cable works in process of erection in the South of France. They report having executed a large number of orders for electric stranding machines, electric cable machines, indiarubber and gutta-percha machinery, wire-covering machinery, for the United States, Germany, Italy, and the Continent generally. They have introduced in the manufacture of their machinery a number of improvements with the view of enabling the machines to be run at a very high speed with the minimum amount of attendant labour; this involves the making of the machines in the best possible manner. They are now receiving orders and enquiries for machinery from a much wider area than they formerly did. Russia, Spain, Portugal, the Australian colonies, and even China are now manufacturing electric wire and cables, and there is a prospect of the trade spreading yet further. They undertake the fitting up of cable factories with every requisite from the motor to the largest machine made. As a proof of the heavy character of some of the work recently done, they inform us that they have made several machines weighing each from 48 tons to 50 tons.

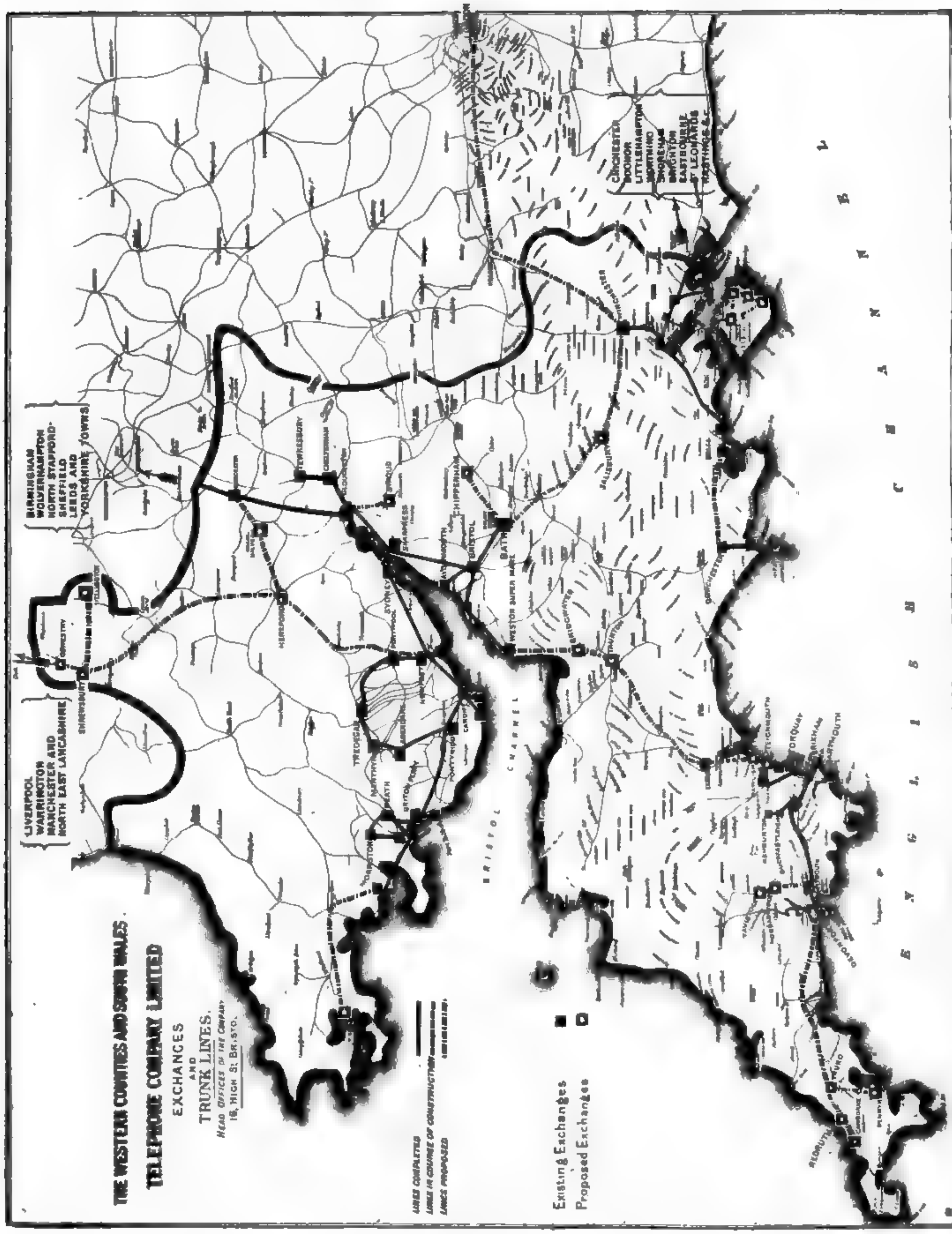
W. T. GOOLDEN AND CO.—The progress of business in the past year has been favourable, the firm having experienced considerable activity in all branches of work, including the supply of dynamos, instruments, and accessories for central station work, and the supply and fitting up of electric installations in private houses and mansions, worked by steam and water power. They have also been very busy with the electric mining work, including plants for pumping, hauling, winding, rock drilling, and coalcutting. Motor work for workshops, launches, etc., has also been fairly good. The prospects for the coming year appear to be fairly good.

JAMES MACINTYRE AND CO. are makers of porcelain only for the use of electrical engineers. The trade is undoubtedly increasing as far as this firm is concerned, and they find it difficult, particularly at this time of the year, to keep pace with the demand for switches, ceiling roses, and the like. Much more care and consideration is being given to the decoration of these articles, many of which are now of an elaborate and artistic character. Perhaps the greatest improvement in porcelain is the tapping of holes to take British Association threads; by this means the small brass attachments are screwed direct into the porcelain, thus avoiding the nut at the back, and therefore improving insulation considerably.

SWINBURNE AND CO.—This firm reports that their business in transformers has largely increased during the past year. They find the demand for their type of transformer gradually growing both at home and abroad. During the year they have also brought out alternating-current condensers, as many engineers thought the exciting currents of their transformers would give trouble. Except with station engineers, who still think an idle current means power, the trouble has never come up in practice; but there has been some demand for condensers, as there is a great deal of experimental work on motors and other apparatus involving them. They have also brought out alternating-current gear for testing cables under high pressures. They are now making a plant to give 40,000 volts and three amperes for the Silvertown Company, who wish to test cables by the mile under high pressures. Messrs. Swinburne and Co. are now bringing out specialities in instruments for central station work—their wattmeter for transformer testing having been already described in this journal. They have introduced a practice which should not be new in transformer business, but is novel—keeping a large stock ready for delivery. They say that more of their increased business is due to this than to theoretical efficiencies of the highest order.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY, LIMITED; head office, 16, High-street, Bristol. Under the energetic and able management of Mr. H. F. Lewis, this company continues to make good progress in its district. How large this is and how far it has been exploited will be seen from the accompanying map showing the lines completed, in course of construction, and proposed. In December, 1891, the number of exchanges was 46, and the number of exchange private and trunk renters, 4,066. The following is a list of the exchanges open: Bristol and Clifton, Bath, Weston-super-Mare, Gloucester, Cheltenham, Tewkesbury, Newport, Cardiff (two exchanges, connected by local trunks),

Barry, Penarth, Pontypool, Pontypridd, Aberdare, Merthyr, Tredegar, Swansea, Neath, Briton Ferry, Port Talbot, Morriston, Llanelly, Shrewsbury, Worcester, Plymouth, Devonport, Mutley, Torquay, ampton, Winchester, Weymouth. The company has 313 employés. It has an extensive trunk line system at present in three groups—viz.: (1) Bristol, Bath, Weston-super-Mare, Gloucester, Cheltenham, Wor-



Newton Abbot, Paignton, Totnes, Brixham, Dartmouth, Buckfastleigh, Ashburton, Exeter, Portsmouth (two exchanges, connected by local trunks), *Boscombe*, Christchurch, Bournemouth, Poole, Southcester, Newport, Pontypool, Cardiff, Penarth, Barry, Pontypridd, Aberdare, Merthyr, Tredegar, Briton Ferry, Port Talbot, Morriston, Neath, Swansea and Llanelly with each other, and also

with Birmingham and Wolverhampton, and other Midland towns of the National Company's district. (2) Plymouth, Plympton, Ivybridge, Totnes, Paignton, Torquay, Newton Abbot, Brixham, Dartmouth, Buckfastleigh, and Ashburton. (3) Portsmouth, Southampton, Winchester, Bournemouth, and Poole. The above comprises 500 route miles, and 2,330 miles of wire. Exeter is on the eve of being included in No. 2 group. The lines to that city from Torquay will be completed this month. The number of communications on the company's trunk lines have increased from 284,886 in 1888 to 550,500 in 1891, and, taking the latter year as an instance, the trunk communication between towns only averaged 1½d. each. From Weston-super-Mare to Worcester, all within the company's district, is 150 miles by the route taken. The following statistics will be interesting:

TELEPHONIC COMMUNICATIONS OR MESSAGES.

	1885.	1886.	1887.	1888.	1889.	1890.	1891.
Trunk......	——	——	54,676	284,886	369,508	498,320	550,500*
Local	1,193,334	1,942,044	2,811,426	3,909,856	4,963,944	6,045,168	6,605,000*
Total	1,193,334	1,942,044	2,866,102	4,194,742	5,333,452	6,543,488	7,155,500*
Gr'ss revenue for the year	£2,730†	£9,914	£15,569	£21,845	£26,803	£32,837	‡

* Month of December, 1891, estimated. † 16 months. ‡ Accounts not completed.

Wire mileage on 31st December, 1890.—Exchange and private lines, 2,836. Trunk lines, 2,182. Total, 5,018 miles.

The company has erected a signal station at Rame Head, which is a prominent point seven miles from Plymouth, and is the nearest land to the Eddystone Lighthouse. This they have connected with their Plymouth and Devonport exchange system, and they hope to open this signal station for signalling to and from ships passing up and down Channel, or entering or leaving the port of Plymouth, this month. The Plymouth exchange is connected with the post office in that town by telephone, and arrangements are being made with the Post Office by which telegrams can be received at Plymouth and telephoned to Rame Head and thence signalled to ships or *vice versâ*. The station will be open continuously day and night and Sundays.

SYDNEY F. WALKER.—Mr. Walker writes a characteristic letter, which contains much that some people think but are afraid to say. We give the following extracts: "With regard to work, I have been fairly busy during the year — not as busy as I should have liked—but it has been in my own specialities. London firms, and young firms hailing from nowhere, have been so anxious to secure contracts at something less than cost, if the work was to be carried out properly, that as I could not afford to lose money, nor to do bad work, I am waiting till the clouds roll by for the showy part of the business. So far as I can understand, the present problem in electrical engineering is, not to get work, but to make a satisfactory profit, considering the amount of labour and skill required. What with having to stand by your work, no matter what comes against it, to stand the loss involved by slips of—some other fellow—the little eccentricities usually adopted by electrical engineers when they get a chance to put a spoke in the wheel of a rival, and the cost of tendering, the life of an electrical engineer on his own hook "is not a happy one." With regard to the matter of tenders, I have partly carried out the plan sketched in the article I contributed to your columns. Where a tender involves expense, I do not tender unless within a certain radius of Cardiff, unless I am paid for it, except, of course, in special cases where there is a reasonable hope of return. As a result, the tenders I have given during the year have been much reduced, and my business is considerably healthier in consequence. The cool enquiries one gets at times under the pretence of asking for tenders are exasperating in the extreme. In some cases, it is not too much to say that they are on a level with some of the swindles that are frequently exposed in the papers. A man out of pure curiosity wants to know what it would cost to light his town or village. Another has water power a little way off, steam here, something else there. He is not sure what he wants—doesn't know the power of his fall, what steam he has, or, in fact, anything; but he will condescend to let contractors spend time and money coaching him up in their views, finding out all that he ought to pay an expert for, and finally perhaps he will—*think of it another time*. It never occurs to him that if you asked him and several others to give you, say, a truck load or 1,000 tons of the material he sells, on the chance of your buying some later on, that he would open his eyes very wide indeed. So far as I am concerned, except under the conditions I have named, or in special cases, some other fellow will do the tendering."

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

STEAM ENGINE ECONOMY.

SIR,—It is said by one of your contemporaries in last week's issue, that in a report to the Portsmouth Town Council Prof. Garnett has stated that the Parsons turbo-generator is now "as efficient as the best compound engine of the marine type, and that for light loads it stands unequalled." The authority for these statements is said to be the report by Prof. Ewing, F.R.S., published in your paper for last week.

Those interested in the "best compound engines of the marine type" (as electric light engines) will no doubt take care of their own credit, but the continental users of direct-coupled condensing engines of this pattern will perhaps be surprised to hear that a plant which uses 27·6lb. of water per electrical horse power per hour, when working condensing, is formally stated in a report by the electrical expert of one of the most important English towns to be as efficient as their own.

Our concern is with the statement that "for light loads it (the turbo-generator) stands unequalled." We beg to assure Prof. Garnett that there are no figures in Prof. Ewing's report which bear this out. At low temperatures the turbo-generator is, for obvious reasons, *relatively* a more efficient machine than an expansive steam engine; but at no power quoted (not even at *no* electrical load, at which even an alternating station can hardly want to run) is the consumption nearly so low as that in the best Willans engines with direct-driven dynamos—of course, when the latter were working condensing. At full load the consumption of the turbo-generator reaches, as above stated, to 27·6lb. per electrical horse-power, a figure usually surpassed by the Willans *non*-condensing engine. In many recent trials of a Willans condensing engine (of much smaller power than the turbo-generator tried at Newcastle; in fact, indicating only from 30 h.p. to 40 h.p.) the consumption per indicated horse-power per hour has been about 12·8lb. of steam. With a combined efficiency of 80 per cent., which is the lowest we are accustomed to get with good dynamos, this corresponds with 16lb. per electrical horse-power per hour.

These figures, which are recent, are probably not known to Prof. Garnett, but Prof. Ewing's report speaks of published trials with a Willans engine, in which the consumption was about 25lb. per unit, or, say, 18·6lb. per electrical horse-power. Yet Prof. Garnett totally ignores these figures from an actual engine (compared with which those of the turbo-generator are *about half as large again*), and makes comparison with nothing but an engine of a kind which no one in this country would be likely to use, whereas the Willans

engine is used in England (for central stations) to the extent probably of 2 h.p. for every 1 h.p. of all other kinds of engines put together. Thus in the comparative estimates stated to have been drawn up for the guidance of the town councillors, the cost of an installation of turbo-generators is compared with that—not of Willans engines, or of any other form of direct-driven plant—but with an absurdly obsolete plant, consisting of engines "making not more than 90 revolutions per minute, coupled by endless rope gearing to dynamos making 300 revolutions per minute."—Yours, etc., WILLANS AND ROBINSON, LIMITED.

Jan. 13, 1892. C. S. Essex (Secretary).

OUR PORTRAITS.

Kapp, Gisbert, M.I.C.E., M.I.E.E. Born at Mauer, near Vienna, in 1852; educated at the Polytechnic School n Zurich, where he studied under Zeuner and Kohlrausch, and gained his diploma of mechanical engineer. For some years Mr. Kapp was engaged in purely engineering work, coming into contact with electrical work at the Vienna Exhibition. It was not till 1882 he made his fixed residence in England, having been travelling on the Continent and in North Africa for some years. In 1882, however, we find him engaged with Messrs. Crompton and Co., and he soon began to make his name known in the profession. Since then Mr. Kapp has been connected either in conjunction with others or individually in taking out a number of patents. His name is intimately connected with the development of the dynamo, with compound winding, and with electromagnetic measuring instruments. A large number of exceedingly practical papers have come from his pen, and his work on "Transmission of Power," published by Whittaker and Co., has passed through several editions, and is acknowledged as *the* text-book on the subject. At the present time Mr. Kapp is completing a monograph on "Dynamos, Alternators, and Motors," to be published shortly by Messrs. Biggs and Co. In 1885, Mr. Kapp severed his connection with Messrs. Crompton and Co., and for a period undertook the London editorship of *Industries*. When, however, the principal office was removed from Manchester to London he left the paper, and has since devoted his whole attention to the business of a consulting electrical engineer.

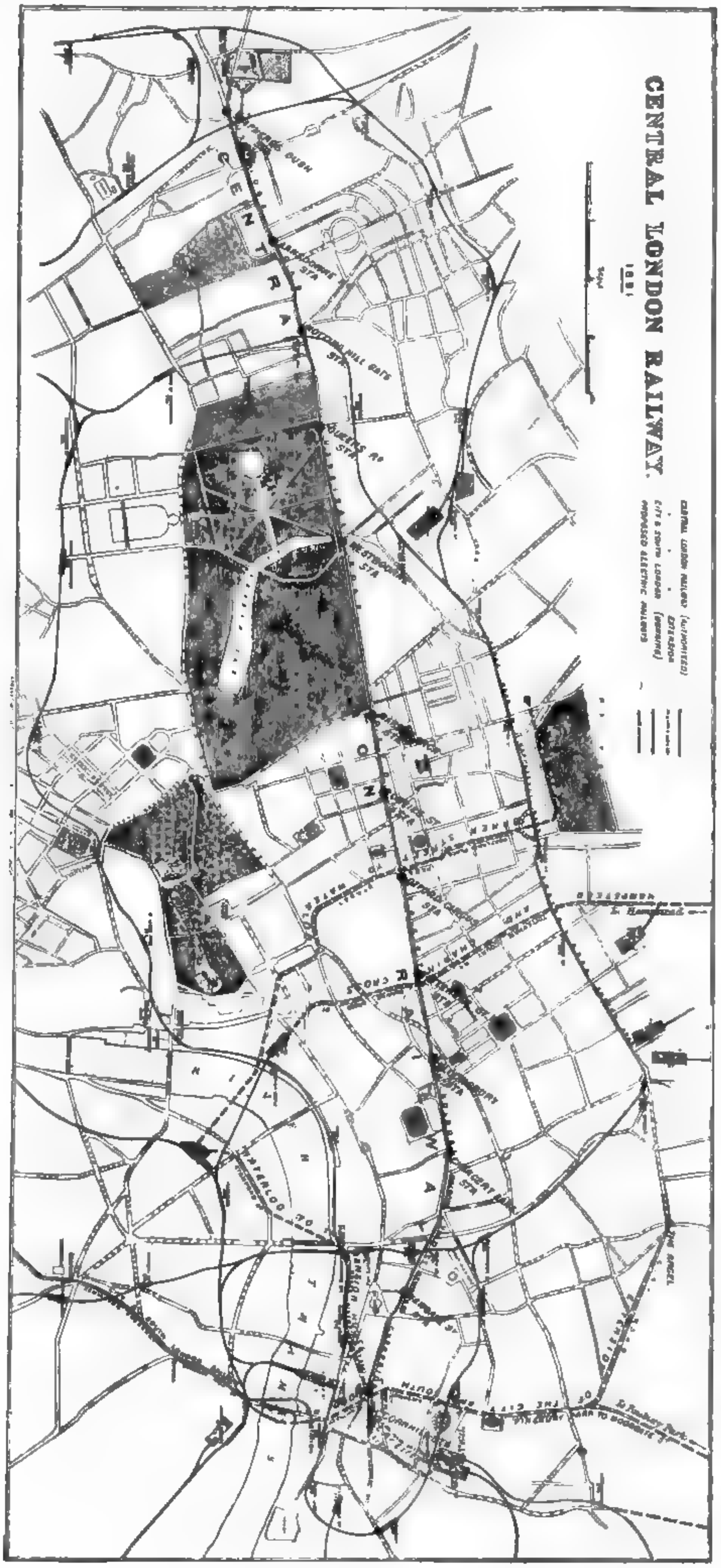
Albright, J. F., C.E., M.I.E.E. Born in Birmingham, 1857; was educated as an engineer, partly at the Crystal Palace Engineering School, and subsequently three years as pupil with the late Sir J. Bazalgette. In the year 1880 Mr. Albright entered into electrical work with the Swan Company at Newcastle-on-Tyne. His first employment was on the "Servia," and afterwards he took charge of the company's exhibits at the 1882 exhibition at the Crystal Palace. For a time Mr. Albright was with the amalgamated Edison-Swan Company, and ultimately took charge of this company's contracting department, a position held till the spring of 1884, when he entered as a partner into the firm of Messrs. R. E. Crompton and Co. When this firm became a limited company, Mr. Albright became managing director. Our acquaintance with Mr. Albright dates back to a time previous to his entering the ranks of the industry, and each step in his career has shown him to possess the true instincts that combine to make a first-rate man of business. We fancy he would be the first to repudiate the view that electrical work necessitated too great a deference to mere theory, but would maintain that practical considerations more often regulate commercial production than do theoretic ones. Quite recently Mr. Albright made what may be called a tour of the world, with a view of opening up new fields for the company's productions, and of extending the branches already existing. Besides his connection with the parent company, he is chairman of the Crompton-Howell Storage Battery Company, and a director of the Crompton Supply Company of Australia.

Gordon, J. E. H., M.I.C.E., M.I.E.E., born in 1852, is the son of the late Dr. J. A. Gordon, F.R.S. He was educated at Eton, King's College, London, and Cambridge, where he took his B.A. degree in mathematics, subsequently working under Clerk Maxwell in the physical laboratory. In 1878 Mr. Gordon accepted the appointment of assistant secretary to the British Association, an appointment, however, which he held only two years, for he soon became interested in the construction of dynamos. The outcome of this work was his dynamo constructed by the Telegraph Construction and Maintenance Company at Greenwich, which paved the way for the Paddington installation, under Mr. Gordon's system. The plant at Paddington was started on April 21st, 1886, and is still at work. It was, however, decided by the company with which Mr. Gordon had been working not to continue electric lighting work, so he made arrangements to form the Whitehall Company, an installation which subsequently formed the nucleus of the Metropolitan Company's undertaking. Mr. Gordon was elected a director of the Metropolitan Company at its formation, afterwards retiring and throwing all his energies into consulting and contracting work. Mr. Rivington joined Mr. Gordon, and the firm registered the business as a company in 1890. Of late Messrs. J. E. H. Gordon and Co. have been very active in installation work. A description of their Carlow (Ireland) installation has been given in this paper, and their latest work at Sydenham, where a fine central station has been built and equipped in a very short space of time for the Electric Installation Company.

Reckenzaun, Anthony, M.I.E.E. Born, and educated, at Gratz in 1852. Like most successful electrical engineers, Mr. Reckenzaun was originally trained as a mechanical engineer. Coming to England in 1872, he entered the employ of Messrs. Ravenhill and Miller, afterwards Messrs. Easton and Anderson. While with Messrs. Easton and Anderson he qualified as a teacher under the Science and Art Department, and established evening classes for the employés. Subsequently he attended lectures at the School of Mines, and at Finsbury. Feeling a great interest in electrical matters, Mr. Reckenzaun made a thorough study of the apparatus at the Paris Exhibition in 1881, then joined the Faure Company, but soon after accepted the position of electrical engineer to the Electrical Power Storage Company. Here he turned his attention to traction, a branch of the industry with which his name has since been intimately connected. Storage batteries have also been carefully studied, and their capabilities investigated. In fact, Mr. Reckenzaun has perhaps done more than anyone to show, by his practical work, and by various papers, the value he places upon storage batteries in all kinds of electrical work. He spent a year or so in America, successfully fighting the fight of such batteries. More recently he has been closely allied with Mr. Binswanger, with the Keys' Company, and, lastly, with Messrs. Greenwood and Batley. Mr. Reckenzaun has reached his acknowledged position as one of our foremost experts in batteries and traction, because of the painstaking industry and skill with which he investigates every problem connected therewith.

Gray, Robert Kaye. Born 1851, in Glasgow. Educated at the Greenock Academy, University School and College, London, and in Paris. In 1869 Mr. Gray was on the staff of the late Sir Charles Bright in the capacity of a telegraph engineer, and was employed in the West Indies. In 1871 he transferred his services to the India Rubber, Gutta Percha, and Telegraph Works Company, acting as engineer and electrician. He has remained with the company ever since, gradually rising to the post of engineer-in-chief. Since he has been with the company Mr. Gray has taken part in a number of cable-laying and repairing expeditions in the West Indies, and on the coasts of North and South America. In this connection we may mention that the "Dacia," one of the India Rubber Company's cable ships, was fitted throughout with electric light so far back as 1879. We believe that she was the first ship to be completely lighted in this way. Of late years, Mr. Gray has not been so intimately connected with the engineering branch of cable enterprise, or, in fact, any electrical work, as with the management of the business operations connected with the direction of cable and other companies of the boards of which he is a member.

CENTRAL LONDON RAILWAY.



The accompanying map will show our readers the magnitude of the proposed work, and the district it is intended to serve. There is no doubt that the traffic in London is of vast magnitude, and that the opening up of new routes gives little or no relief to the old ones. In fact, the traffic seems to increase quite as fast as new routes are opened. The Exploration Company, which has taken the initiative in this proposed work, has endeavoured to educate the public and to explain its views by issuing an admirable map with descriptions of the railway. From their map the one given by us has been prepared. An examination of it will show the proposed depôt at Shepherd's Bush, and the various stations, taking them in order from the depôt, show the direction the line will take. Thus we have Shepherd's Bush, Lansdowne-road, Notting Hill Gate, Queen's-road, Westbourne, Marble Arch, Davies-street, Oxford-circus, Tottenham Court-road, Bloomsbury, Chancery - lane, Newgate-street, Cornhill, with an extension to the Liverpool-street Station of the Great Eastern Railway. There is a vast population to be served by such a line, and we cannot see any reason, if the matter be managed with a due regard to economy in construction, why this line should not be eminently satisfactory. It is proposed to work it electrically, thus obviating many of the troubles which arise from the use of steam. But we shall have much more to say on the scheme at a future date. Meanwhile, the map, as we say, will tend to show what is the intention of the promoters. It also indicates the route proposed to be taken by the other underground railways for which Bills have been deposited in Parliament. Thus we have the Baker-street to Waterloo line; that which is to run between Hampstead and Charing Cross; the Waterloo and City line; and the City and South London extension to The Angel, Islington. It is far from likely that all these schemes will be passed during the ensuing session, but that most of them will become accomplished facts in the course of a few years is more than probable. A railway between North and South London is badly wanted, so is a line between the West and the City, as well as on from Waterloo to the Mansion House.

INDIAN TELEGRAPHS.

From the Government resolution on the report on Indian telegraphs during the past year, it appears that the additions to the system were 1,791 miles of line, 7,373 miles of wire, and 21 miles of cable. At the close of the year there were in operation 37,070 miles, 113,512 miles, and 251 miles of line, wire, and cable respectively; 168 new offices had been opened during the year, bringing the number to 3,103. The gross receipts for the year, including State-paid messages, amounted to 68,28,855 rupees, and working expenses to 46,88,802 rupees, showing a profit equal to 4·126 per cent. on the capital outlay. The receipts from telegraphic money order advices have steadily risen from 46,000 rupees in 1888 to 84,000 rupees in 1891. During the year excellent work was done by the Department in laying field telegraph lines. The Sikkim line was maintained, as also that in the Chin country. A new line in the Assam section of the Chin-Lushai country was laid for a distance of 59 miles, through a most difficult and unhealthy country. The working parties suffered severely from sickness, one officer losing his life and another being invalided. For the Hazara expedition 182 miles of extra wire had to be laid to connect Hussan Abdul and Abbottabad with the bases of operation at Derband and Oghi, and from those points onwards 103 miles of field wire were laid and 15 offices opened. The receipts of the telephone companies at Calcutta, Madras, Bombay, Kurrachee, Moulmein, and Rangoon show a small increase of 10,657 rupees, while the number of subscribers is now 1,004 against 961 in the previous year. The charges per word between India and the Straits Settlements have been reduced, partly by reductions in the Indian terminal and transit rates, and partly by reductions in the Eastern Extension Company's rates. The transit rate claimed by India for messages passing between Europe and the Far East was largely reduced. By the connection of the French lines in Tonquin with China, a new and cheap route for messages to the latter country *viâ* Siam has been opened.—*Times.*

NEW FLEXIBLE METALLIC TUBING.

A new kind of tubing, of interest to steam power users and electrical engineers, is being manufactured by the Flexible Metallic Tubing Company, of 48, Parker-street, Holborn, W.C.

The tubing is flexible, and is made in a machine from metal strips of the necessary length, width, and thickness, according to the purpose for which it is required. In passing through the machine the strips, which are of steel, galvanised steel, or otherwise, have formed upon one side two corrugations in a longitudinal direction, one being large and the other small. The corrugated strip is then coiled in the form of a spiral round a mandrel, this operation being so performed that the small corrugation enters the large corrugation and interlocks with it. This forms what is known as a piston joint. The tubing, which is unaffected by ordinary liquids or gases, has been tested both at high and low pressures—steam up to 60lb. and hydraulic up to 1,000lb. to the square inch. The tubes are made from $\frac{5}{16}$in. to 3in. internal diameter, and plant is now being laid down for the manufacture of tubes up to 12in. diameter. This kind of tubing is now in use for a variety of purposes, including for gas and steam pipes, compressed air, speaking tubes, and also as sheathing for electric light cables, whilst it can likewise be used for running ordinary house leads. A special type of coupling, which will not give way under the pressures mentioned, is used for joining lengths of tubing.

A Chance for Amateurs.—An idea that is worth consideration and imitation has been started at Chicago to induce all the amateur electrical societies to combine in making a united exhibit at the exposition. It is quite possible that among much "tinpot" electrical inventions something really good and useful might be discovered.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

II.

(Continued from page 17.)

UNITS, *continued.*

Ohm, continued.—In addition to the foregoing recognised values of the unit of resistance, a new value has recently been proposed by the Electrical Standards Committee appointed by the Board of Trade.* Its value is equal to the resistance of a uniform column of pure mercury of 1 square millimetre section, and 106·30 centimetres long, at a temperature of 0deg. C., this being taken by the Committee as most nearly approaching the absolute theoretical value of the unit. It will probably be known as the Board of Trade or the Imperial Ohm, and is likely to be made the legal unit of electrical resistance for this country by an Order in Council under the Weights and Measures Act. In order to show the relation of this unit to the various others given in Table 1, page 17, of the issue of 1st January, we reproduce this table below, with the Board of Trade Ohm included in it.

TABLE 1.—RELATIVE VALUES OF THE VARIOUS "OHMS."

Description of "Ohm."	Length of mercury column 1 sq. mm. section and at 0° C.	Values expressed in terms of		
		B.A. Ohm.	Legal Ohm.	True Ohm.
	Centimetres			
Siemens Ohm	100·00	0·9541	0·9435	0·9411
B.A. Ohm	104·82	1·0000	0·9889	0·9864
Kohlrausch Ohm ...	104·93	1·0010	0·9899	0·9874
Legal Ohm	106·00	1·0113	1·0000	0·9975
True Ohm...............	106·27	1·0139	1·0026	1·0000
Board of Trade Ohm	106·30	1·0141	1·0028	1·0002
"Baltimore" Ohm..	106·34	1·0146	1·0033	1·0006

Volt.—The fundamental definition of the unit of Electrical "Pressure," Difference of Potential, or Electromotive Force (usually written E.M.F.), the *Volt*, is the Electromotive Force which is generated in a conductor when it is made to cut across magnetic lines of force at the rate of one hundred million (10^8) per second.

Unit Electromotive Force can also be defined in terms of the units of Resistance and Current, thus: One *Volt* is that Difference of Potential which must be maintained between the two ends of a conductor whose resistance is one Ohm, in order to keep a current of one Ampere flowing steadily through it.

The E.M.F. of a newly made-up Daniell cell is about 1·1 Volt, and that of a Latimer Clark standard cell varies from 1·471 to 1·435 Volt with a range of temperature of 0deg. C. to 32deg. C.

Ampere.—The unit of Rate of Flow of an electric current, the *Ampere*, is that current which will flow through a wire having a Resistance of one Ohm, when a Difference of Potential or Electrical "Pressure" of one Volt is maintained between its two ends.

A current of one Ampere will deposit in one hour 1·174 grammes or 18·116 grains of Copper in a copper electrolytic cell, and 4·074 grammes or 60·52 grains of Silver in a silver electrolytic cell; and will decompose 0·3357 grammes or 5·180 grains of slightly acidulated water in the same period.

Ohm's Law.—It will be observed that the second definition of the Volt, and the definition of the Ampere are merely two different statements of the same thing; and the Ohm could also be defined in precisely the same terms. All these are simply statements from different points of view of the well-known Ohm's Law, which in its simplest form may be shortly stated as follows:

The current in Amperes flowing through any conductor is equal to the difference of potential in Volts between any two points in this conductor, divided by the resistance in Ohms between these two points.

* See *Electrical Engineer*, September 11th, 1891, page 262.

Thus, if C be the current in Amperes flowing through any circuit;
E the difference of potential in Volts between any two points in it;
and R the resistance in Ohms between these two points; then

$$C = \frac{E}{R};$$
$$E = CR;$$
$$\text{and } R = \frac{E}{C}.$$

This law was originally enunciated by Ohm in the year 1827 as the result of a series of experiments carried out by him, and it has since been verified by investigations made at the Cavendish Laboratory in Cambridge.

Watt.—The electrical unit of Power, or rate of doing Work, the *Watt*, is the electrical unit which corresponds to the mechanical term Horse-power, of which it is simply a sub-multiple. The power transmitted by the current, or the energy developed in the circuit, when a current of one ampere flows through a conductor whose resistance is one ohm, is termed one Watt.

1 watt is numerically equal to 1 ampere × 1 volt;
or if C represents the current in amperes,
E „ „ electromotive force in volts,
R „ „ resistance in ohms,
and W „ „ power in watts,
in any circuit; then

$$W = C \times E; \text{ and from Ohm's law}$$

we may write $$W = \frac{E}{R} \times E = \frac{E^2}{R},$$

and $$W = C \times CR = C^2R.$$

Expressed in terms of the mechanical unit, one watt is = $\frac{1}{746}$th of a horse-power,

$$= \frac{33{,}000}{746} = 44 \cdot 25 \text{ foot-lbs. per minute.}$$

Thus, if a current of C amperes is flowing through a circuit whose resistance is R ohms, the total difference of potential being E volts, then the power developed in that circuit is =

$$\left.\begin{array}{l} C \times E, \\ \text{or } \frac{E^2}{R}, \\ \text{or } C^2R \end{array}\right\} \text{Watts;}$$

$$\left.\begin{array}{l} = \frac{CE}{746}, \\ \text{or } \frac{E^2}{746\,R}, \\ \text{or } \frac{C^2R}{746} \end{array}\right\} \text{Electrical Horse-power.}$$

Joule.—The electrical unit of Work or Energy, the *Joule*, expresses the work performed, or the heat liberated, in one second when a current of one ampere is forced through a conductor whose resistance is one ohm; or, in other words, one Joule represents the work done per second in a circuit in which a power of one Watt is being developed.

Thus, if in addition to the quantities represented in last paragraph,
J represents the energy in joules,
and T „ „ time in seconds,
then

$$J = WT,$$
$$= CET,$$
$$= \frac{E^2T}{R},$$
$$= C^2RT.$$

One Joule is equivalent to $\frac{33{,}000}{746 \times 60} = 0{\cdot}7373$ foot-lbs.

Coulomb.—The unit of Quantity of Electricity, the *Coulomb*, is the quantity of electricity carried in one second past any cross-section of a conductor through which a current of one ampere is flowing. An ampere is therefore equal to a coulomb per second, or a coulomb is equal to an ampere-second.

Thus, writing Q for the quantity of electricity in coulombs, and taking the other values as in the last two paragraphs, we have

$$Q = CT,$$
$$= \frac{ET}{R}.$$

The coulomb is chiefly used in connection with electro-chemistry.

(*To be continued.*)

ELECTRIC DRILLS.

The portable electric drills with flexible driving shafts, made by MM. Sautter, Harlé, and Cie., illustrated herewith, have been used in considerable numbers in ship-building yards, arsenals, and boiler works. They are equally serviceable in large works for the construction and erection of bridges, mining work, the construction of railway lines, and so forth. It may be said that their use is advisable in any case where it is easier to mount the tool on the work than to take the work to the tool. Further, this machine tool is capable of being used not only for wood and metal drills, but with other machine tools and polishing brushes.

MM. Sautter, Harlé, and Cie. have made these electric drills part of their regular manufacture. The following are particulars of these tools given in the *Revue Industrielle.*

Every installation of this kind comprises essentially a dynamo, one or several electromotors to which the tools are adapted by means of flexible shafting, and the necessary conductors leading from dynamo to the motors. The conductors are generally supported by porcelain insulators fixed on poles at distances of 30 to 50 yards. The dynamo is fixed at the centre of distribution, though sometimes the dynamo used for lighting is used concurrently for the transmission of power. The electric pressure varies according to circumstances, usually between 50 and 120 volts; that of 70 volts is most ordinarily used. Connections which are easy to make and unmake lead the current by means of insulated twin wires to electromotors which drive the machine drills by the intermediary of flexible shafting.

Figs. 2 and 4 represent the arrangement adopted by MM. Sautter, Harlé, and Cie. These are of two types. The dimensions of the smaller model are shown in the illustration. The following are the further details of this type, and of the larger one:

No. of revolutions per minute of the motor	2,000	2,000
„ „ „ of the shafting	475	450
Power in watts absorbed	700	1,100
Weight	68lb.	103lb.

As is seen, the angular velocity in revolutions per minute of the motor is very greatly reduced in the tool itself by spur gearing.

In the special case of the application of electric drills to shipbuilding, MM. Sautter, Harlé, and Cie. have worked out a convenient system of conductors by means of copper strips, F, fixed on boards run the length of the ship in construction; drums or posts, E, capable of carrying a certain length of twin conductor, D (Fig. 1), are fixed to supports with double contacts pressing on the copper strips, from which the current is drawn as desired.

In the usual case where overhead conductors are used, or in special cases for shipbuilding, the twin conductors, D, of 12 or 15 yards length, are terminated by a connecting plug, which can be inserted in one of two holes arranged for this purpose in a regulating resistance-box, R, which is furnished with a hand commutator. In the second plug-hole is inserted the plug attached to one end of the twin wire, G, four or five yards long, the other end of which is attached to the terminals of the motor.

The resistance is used to regulate the difference of potential necessary at the terminals of the motor according to the work in hand. It is also used to prevent the motor overrunning when running light.

The conductors are furnished with fuses at the dynamo end, and at each branch. This avoids the burning of insulation, or fear of the belt coming off in cases of accidental contact of the conductors. Near the dynamo is usually a switchboard with ampere-meter, voltmeter, cut-outs, and field-magnet resistance, etc. Certain of the accessories,

such as cut-outs, field-magnet resistances, measuring instruments, and so forth, are not indispensable, but are always advisable in an installation of any importance.

A clamp suitable to each special case serves to fasten the tool-carrier, P, on the piece of work to be drilled, B. The connection of motor to tool is easily made by means of the flexible shafting, the motor standing on the floor or in any convenient position. The feeding of the drill is brought about by hand by the movement of the wheel, C,

In actual work the flexible is kept from too sudden curves, more particularly in the vertical direction, as the weight of the flexible tends to loosen coupling-piece at the motor, and to separate the leather sheath from the threaded socket. It sometimes happens that the cores of the flexible shafting break at the extremities, near the sockets to which they are welded. These breakages occur generally at the moment the hole is pierced through, or when in piercing several sheets of iron superposed, the tool bites.

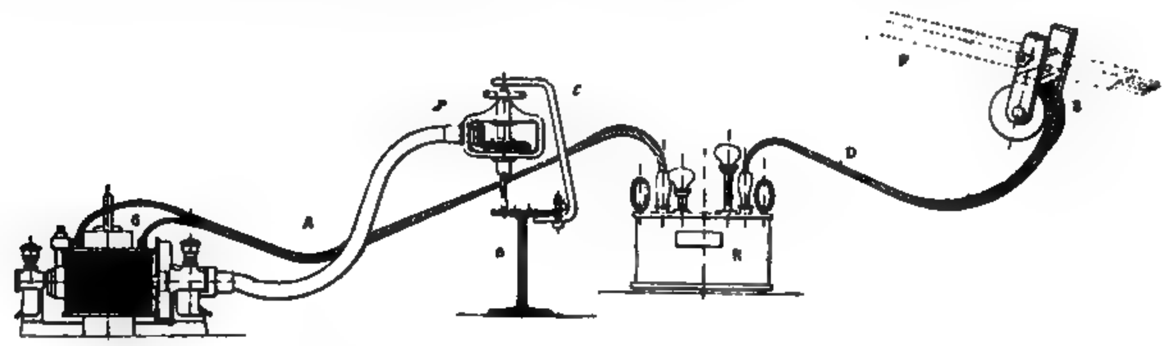


Fig. 1.

mounted on a threaded axle. A movable resistance stand, with a wheel handle switch, gives complete control of the gradual starting and stopping of the motor, and to some extent of its speed.

The difference of potential (constant at the dynamo) and the strength of current vary with the size of drill, depth of working, nature of the metal, and pressure exerted on the tool. The rheostat contacts are numbered 0 to 4, and the various movements can be made with surety and the avoidance of arcing at the contacts.

For iron and soft steel the tangential velocity of the drill may be regulated by means of the rheostat at about 10 cm. (3⅞in.) per second, and the pressure exerted by means of the screw should be such that the feed is about $\frac{1}{10}$ mm. per revolution of the tool. For drills above 28 mm. to 30 mm. (1¼in.) it is well to substitute worm gearing for spur gearing. The core of the flexible shafting and the worm gear should be preferably lubricated with thick grease from mineral oil. Such drilling should be carefully done by screwing the feed very gradually. The core is repaired in the following way: The portion of the metallic core remaining in the socket is first detached; the broken steel wires are then neatly cut with a metal saw, after having bound them together of the section required, and the end of the core is then strongly brazed; this is then filed up to a conical shape, fitting the inside of the socket. The faces of both are carefully washed and wiped several times to remove all trace of dirt or acid. The core is then tin-soldered firmly to the socket, having taken care again to remove all acid to avoid oxidation of the wires. If a breakage occurs at any other part than at the ends, repair is impossible. With workmen used to the management of the tests breakages become rare.

The following table gives the results of several tests made upon an electric drill in the service of the Control of the Marine.

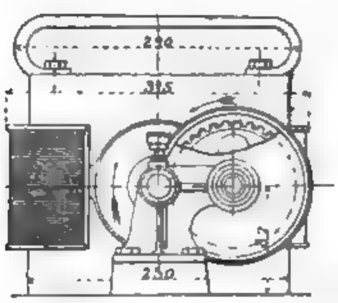


Fig. 2.

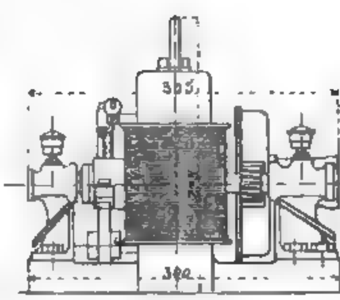


Fig. 3.

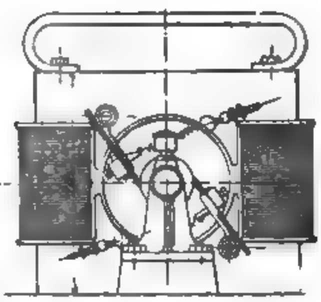


Fig. 4.

It is best to use helicoidal bits or drills with very wide edges, and to take care not to put too much pressure on the feed.

The following table gives some particulars of the flexible shafting and the tool-carriers.

Flexible Shafting.			Drill	
Maximum diameter of holes pierced soft steel.	Normal length of flexible.	Number of revs. of flexible.	Average number of revs. of tool. Spur gear.	Worm gear.
10 to 20 mm.	6ft.	550	140	—
20 to 30 ,,	6ft. 9in.	475	105	[illegible]
30 to 40 ,,	6ft. 9in.	450	90	45
40 to 55 ,,	6ft. 9in.	400	[illegible]	27

These flexible shafting are of the type employed in the French navy, and are of French manufacture, M. Foureau having introduced them from America. The details of the construction were given *Revue Industrielle*, Oct. 11, 1890.

It is well to add that the pressures on the tool may be notably increased when the drill is working intermittently—the progress is then much more rapid.

—	Drill with helicoidal bit 28 mm. (1⅛in.)			Drill with helicoidal bit 36 mm. (1⅜in.).		
Nature of metal	soft Siemens-Martin steel					
Pressure in pounds on the tool	528	704	704	176	528	528
State of bit	new	sharp'n'd	good	good	new	fair
Time required to drill holes 1in. deep..... ...	4′ 30″	9′	4′	30′	3′ 15″	6′
Volts at terminals of motor	68	65	65	50	68	65
Current in amperes......	10	10	10·5	10	15	14
Energy expended in watts	680	650	682	500	1,020	910

Speaking generally, the figures given in this table show that the energy expended and the duration of the work vary according to the sharpening of the bit and the pressure exerted upon it. These differences may become

more accentuated when working upon different metals, the other conditions remaining the same.

Ordinary workmen, and even labourers, very rapidly are able to make good use of the electric drills. Practice has shown that the relation between the two sets of tools one working by hand with ratchet brace, and the other with electric drill, is as one to five or six; the quality of the work is at least equal to that of handwork. These observations, made many times by the managers of workshops, serve to indicate the usefulness of these kinds of machine tools.

GLASGOW.

At the meeting of the Council last week the question of the working of the tramways by the Corporation arose for discussion, about which the following information may be found interesting as giving some idea of the views being taken by the Council. One minute of the Tramway Committee reads that: "A sub-committee met with a deputation from the directors of the tramway company, consisting of Messrs. Young, Reid, Faill, and Pettigrew, with Mr. Duncan, secretary and manager, and Mr. Boyd Anderson, law agent. The chairman explained at once to the deputation that the sub-committee had had the company's letter before them, but that the sub-committee have no power to do anything further than to endeavour to make arrangements with the present lessees for the acquisition of their stables and plant, or such portions thereof as may be necessary for carrying on the working of the tramways on the expiry of the lease. The deputation urged that they should be informed what lines the Corporation propose to commence to work on the expiry of the lease by mechanical haulage. The sub-committee, in reply, informed the deputation that they were of opinion that the subject of the request has no relevancy to the matter which the sub-committee are now prepared to discuss with the deputation, but that in any case the sub-committee are not in a position to give the information, as no resolution on the subject has yet been come to. The deputation thereafter urged that till this is arranged the question of the transfer of the company's stabling and plant should be left over. They were informed, however, in reply, that any arrangement on this latter point must be come to without delay, so that the Corporation may know what stabling, car-sheds, and other working plant they will require to provide themselves. After considerable conversation, the deputation agreed that they would consider what portions of their stabling and plant they would be willing to sell to the Corporation, and would submit an offer of it to the committee for their consideration."

Another and subsequent minute reads: "The sub-committee appointed to prepare a statement showing the comparative cost of working tramways by the various methods of haulage, reported that they had considered the remit and the offers submitted by the General Electric Power and Traction Company, Limited, and by the Electric Storage Company, for working cars on the accumulator system, and that adding thereto such other items as seemed necessary to bring the whole cost of working by that system on a parity with the cost of working by animal power, they found there would be a saving of about 1d. per car mile run on the former as compared with the latter system. There was submitted a communication, dated 22nd inst., from the Tramway Company, making proposals whereby the Corporation might, if so desired, acquire the whole of the properties and plant used by the company in conducting the tramway portion of their business, or only certain specified portions thereof. These proposals were remitted to a sub-committee, consisting of Bailies Paton and M'Farlane, Councillors Colquhoun, Stevenson, and Wallace, for consideration and report. The sub-committee having considered the remit made to them by the Tramways Committee on 22nd inst., and having heard the town clerk on the report by Messrs. Johnstone and Rankine on the condition of the tramway lines, and as to what and when further renewals will probably be required, resolved to recommend that he be instructed to intimate to the company that the Corporation hold them liable to implement the obligation imposed on them by the lease, to hand over the tramways to the Corporation at the end of the lease in as good working condition as when they were given over to them, or otherwise to pay such sum as will enable the Corporation to put the tramways in that condition. That sum is estimated in Messrs. Johnstone and Rankine's report at £77,759."

Bailie Paton, in moving the approval of the minutes, said there were various matters of great importance in them. First of all, they had the report from a sub-committee in regard to the use of electricity as a motor in place of horses. They had gone very carefully into that matter, and with the assistance of the City Chamberlain they had prepared a careful statement, the result of which was that practically they found the offer they had from the General Electric and Traction Company enabled them to do the working of the cars at 1d. per car mile less than the cost in Glasgow at the present time, and 1½d. less than the cost to the largest company in London at the present time. One penny per mile on the mileage run meant about £18,000 per annum. If they took into consideration, also, that the receipts per mile would be greater, as it had been proved by experience where cars were worked by electricity or cable they were always larger than where cars were worked by horses, they would see there was considerable room for saving in the future working of the tramways. The committee would probably, in a short space of time, recommend the Council to adopt, at least on a portion of the lines, the working of the tramways by accumulator motors. The committee had had a meeting with the tramway company in regard to the acquiring of the stables. They had a long and very interesting meeting with the company, the result of which was that the company had now submitted an offer to sell the whole or portions of their plant and stabling. Which of these offers or any of them would be entertained was a matter for future consideration. They had remitted to a sub-committee to look carefully into this matter, and submit a recommendation whether they should buy the whole or only certain portions, either of which proposals the company seemed perfectly willing to entertain. Another matter of vast importance was one with which the Town Council probably had not hitherto been familiar—that was the report which had been submitted by their engineer (Mr. Rankine) regarding the condition of the lines at the termination of the lease. They knew that Mr. Rankine was an extremely fair man, and in the reports, with his usual fairness, he had not attempted to make the lines either better or worse than he had good reason to believe they would be two and a half years hence, at the termination of the lease. If the report was correct, the tramway company would have a very considerable sum of money to pay the Town Council at the termination of the lease. The committee had considered this matter very fully. They had taken the advice of their law agent in the matter, and they had no hesitation in recommending the Town Council to take their stand on the report which they had received from Mr. Rankine.

Mr. Tait seconded.

Questions were asked as to the exact position of parties at the expiration of the lease, and it was explained that the "lines" had to be handed over in as good a condition as when they were taken over. The minutes were then agreed to.

THE ELECTRIC LIGHT AT PORTSMOUTH.

According to the *Hampshire Telegraph*, in accordance with the instructions of the Electric Lighting Committee, Prof. William Garnett has submitted to the Portsmouth Town Council an estimate of capital and current expenditure and receipts for the lighting of the district specified in Schedule B of their provisional order, and of the esplanade between the two piers. The estimate is based upon the assumption that in accordance with the recommendations contained in his report of October 14th last, alternating currents at a pressure of 2,000 volts will be employed for the transmission of energy through the main leads, and that turbo-electric generators, with surface condensers, will be employed. The grammar school has been selected as the point from which the lines of high-tension mains should diverge, and it has been assumed that the distance of the central station from this point will not exceed 500 yards. Prof. Garnett states that if it is impossible to fulfil this condition, the extra cost of mains will be at the rate of £2,700 per mile for the distance between the central station and the grammar school. Concentric mains will be laid from the central station to the grammar school capable of carrying sufficient current for twice the number of lamps for which it is intended at present to provide. These conductors together will serve all the requirements of the station until lamps have been installed equivalent to about 17,000 lamps of 16 c.p. Concentric high-tension mains will be laid from the grammar school along the principal thoroughfares mentioned in Schedule B of the provisional order and Alexandra-road. Along the Commercial-road route as far the corner of Lake-road, and to Southsea as far as the corner of Osborne-road and Palmerston-road, high-tension mains will be laid capable of carrying about twice the current for which provision is at present to be made at the generating station. This will provide for the increased demand which will occur when the system of mains is extended to North End and the Beach Mansions. The cost of extending the lighting system in these directions, including high and low tension mains and transformers, will be at the rate of about £2,600 per mile. For the purpose of public lighting in the streets, instead of arc lamps, placed at distances of 50 yards or more, Prof. Garnett prefers to employ "high efficiency" incandescent lamps of 150 c.p., fixed at distances of about 30 yards. These lamps would be supplied directly from the low-tension conductors, and two of them would require about the same power as a single arc lamp. They would need to be more frequently renewed than ordinary incandescent lamps, and this has been taken into account in the estimate of annual expenditure. If incandescent lamps are adopted, only very light columns will be required for their support, and they will need no attention until they require renewal, while the present lamp columns may be used in most cases. Arc lamps require expensive standards, and cost about £4 each per annum for carbons and trimming, if burning until midnight only. As the conductors along the Clarence Esplanade will be used for public lighting only, so that all the lamps connected with them will be switched on and off together, and as no small lamps are required in this situation during the whole night, it will be convenient to switch the whole of the lights on and off simultaneously by means of a high-tension switch at the point at which the esplanade conductors branch from the mains near the Pier Hotel. On a public promenade the lighting up simultaneously of 90 powerful lights will be effective. For the lights along the Clarence Esplanade arc lamps are less unsuitable than in the streets, but high-power incandescent lamps would meet the requirements of the situation. Though the capital required for the installation of 8,800 private lamps and 200 public lamps is

estimated at little more than £28,000, the professor reminds the committee that it is desirable that borrowing powers should be obtained for a much larger sum, in order to enable extensions to be made to the system from time to time, as the public may demand, without renewed application to the Local Government Board. The cost of the site is an item not included in the capital estimate, and no allowance has been made for the renewal of lamps used for lighting the central station, inasmuch as the blackened lamps taken down from the street columns may be used in the engine-room until they are broken up. So long as the number of private lamps wired is less than the equivalent of 8,800 60-watt lamps, the income will be less than the amount estimated, and the expenses will also be less, but not in the same proportion. There appears, however, to be a reasonable margin to meet this difference, and if the public lighting is undertaken at once the installation may be expected to pay its working expenses and interest on capital actually invested as soon as the number of private lamps wired exceeds 5,000. Prof. Garnett's estimate of the capital required for high-speed generating plant and incandescent lamps for public lighting is £38,285. He places the annual receipts for private and public lighting at £10,800, and the expenditure, including interest on £40,000 at 3½ per cent., at £7,572.

In presenting the scheme summarised above, the Electric Lighting Committee reported at Tuesday's meeting of the Council that they had had reason to reconsider the scheme prepared by Mr. Shoolbred for an electric lighting installation in the borough and the recommendation based upon it, and they had obtained a further report on the subject from Prof. Garnett, which they now submitted for the consideration of the Council. The committee recommended that the resolution of the Council passed on September 8 last, so far as it referred to the adoption of Mr. Shoolbred's scheme, be rescinded, but that this should not apply to so much of such resolution as referred to the borrowing of £60,000. They further recommended that the scheme and report of Prof. Garnett be adopted, and that he be appointed as consulting engineer, and that Messrs. Waller and Manville be appointed as superintendent engineers; the fee for the consulting engineer and the superintendent engineers to be £1,500 together. With the view of carrying out the scheme embodied in Prof. Garnett's report, the committee recommended that they be authorised to acquire a sufficient site for the central station.

Alderman Ellis moved the adoption of the report and briefly related the circumstances under which the committee abandoned the plan submitted by Mr. Shoolbred for that now submitted to the Council for consideration. He stated that Mr. Shoolbred had estimated the annual income to be derived from the electric light and the expenditure at £8,939, leaving a fair margin for profit. Before a definite arrangement had been arrived at a doubt arose as to whether Mr. Shoolbred had not overestimated the revenue, and the committee invited him to meet them and prove that his figures were correct. He failed to satisfy them, and they had no alternative than to dispense with his services, it being clear that he had not taken into consideration the nature of the town he had been called upon to light. Prof. Garnett was called in for consultation, and he expressed an opinion that Mr. Shoolbred's estimate of £10,000 was £2,300 more than could be reasonably anticipated, it being unlikely that they could earn more than £1 for each lamp wired. Moreover, it would be impossible to extend the light beyond the area contained in the provisional order without ruinous cost.

Mr. Beale seconded the resolution.

Mr. Miller observed that Prof. Garnett had been called in to sit in judgment on his rival's scheme.

Alderman Ellis: I object to that.

Mr. Miller: You may object, but I shall say it. If I happened to be a professor I should do the same thing.

Mr. Beale: Right or wrong?

Mr. Miller: Yes; I should try to crab my rival. Continuing, Mr. Miller said that the matter was of considerable importance, for it involved the expenditure of £60,000. Only four months ago the Electric Lighting Committee assured the Council that in selecting Mr. Shoolbred's system they were perfectly right and perfectly safe, and he asked what justification had they now in making a similar representation with regard to Prof. Garnett's plan? He desired to know whether Prof. Garnett had had experience in the matter of electric lighting, and whether he could point to a town in which his system had been adopted in preference to others. Undoubtedly electricity would furnish the light of the future, but he thought that Portsmouth could afford to wait and see what other towns were doing. He moved as an amendment that the consideration of the report be deferred to an adjourned meeting of the Council a fortnight hence.

Mr. Pulljames seconded the amendment, and said that when Mr. Shoolbred's scheme was recommended for adoption he seconded Mr. Miller's amendment that the matter be deferred for three months. They stood alone then, but events had proved that they were not wrong. Possibly, if they adopted the new scheme hurriedly, they might be led astray by Prof. Garnett, as they had been somewhat led astray by Mr. Shoolbred.

Mr. Light asked what previous experience in the installation of the electric light was possessed by Prof. Garnett.

The **Mayor** said the two men engaged with Prof. Garnett were now effecting a public installation at Dublin.

Mr. Miller: Ah! the men engaged with him.

The **Mayor** said the committee had adopted Mr. Shoolbred's scheme on the strength of a report received from a deputation who visited Bradford. The deputation, of whom he was one, were delighted with what they saw of Mr. Shoolbred's scheme in operation there, but they overlooked the fact that Bradford was a compact town, with all its business houses in one centre, whereas Portsmouth was a scattered borough, for which the low-tension system was wholly unfitted.

Alderman Ellis asked that before the amendment was voted upon the Council would empower the committee to purchase a site for the central station. It was necessary that the site should be close to the sea, and in the neighbourhood that the committee had selected there was but one available site without a license upon it, and that site must be purchased before the day was out, or it would be sold the next morning.

The amendment was, however, put to the vote, when it was carried by 16 to 12.

READING ELECTRIC LIGHTING.

The following report has been submitted to the Council by the Highways Committee on the question of electric lighting:

The borough surveyor reported that it was suggested by the Reading Electric Lighting Company that 30 1,200-c.p. lamps be used. These lamps would take the place of 236 5ft. flat flame burners, the cost of which is as follows: Lamps lighted by Corporation, £323. 15s. 11d.; by Simeon's Trustees, £25; by Gas Company (at their own expense, £54. 10s. 6d.; or a total cost of £403. 6s. 5d. per annum for gas lighting, producing 3,776 c.p before 11 p.m. and 1,408 c.p. after 11 p.m.

The cost of lighting, cleaning, and maintaining 30 electric lamps (seven years' contract), each giving 1,200 c.p. throughout the time of lighting, or a total illuminating power of 36,000 c.p., would be £27. 15s. each, or £832. 10s. for 30.

The cost of lighting cleaning, and maintaining 30 electric lamps (seven years' contract), each giving 1,200 c.p. until 11 p.m., reduced to 16 c.p. after 11 p.m., or a total of 36,000 c.p. until 11 p.m., and 480 c.p. after 11 p.m., would be £22. 15s. each, or £682. 10s. for 30 lamps.

From the above figures it will be seen that if electric lamps at 1,200 c.p. all night be adopted, the total cost of lighting the streets shown would be about doubled, whilst the illumination of the streets would be nearly 10 times greater than at present.

If the scheme for 1,200-c.p. lamps, reduced 16-c.p. lamps at 11 p.m. be adopted, the illuminating power would be nearly 10 times greater than at present before 11 p.m., and about one-third of what it is at present after 11 p.m.

It must, however, be borne in mind that the electric lamps would be three times farther apart, on the average, than the gas lamps, and, as the intensity of the light diminishes much more rapidly than the distance from it increases, the average lighting of the streets would, with 1,200-c.p. lamps, be about five times greater than at present. The lighting at the mid-spaces between the lamps would be slightly greater than at present.

With the 16-c.p. lamps the lighting of the mid-spaces between the lamps would be much less than it is at present after 11 p.m.

I am of opinion that it would be much more economical to maintain the lamps at 1,200 c.p. all night than to reduce them to 16 c.p. at 11 p.m.

I think, however, that a saving might be effected in another way. The whole of the street lighting current for the 1,200-c.p. lamps would, in any case, be carried by a set of conductors used for no other purpose, and as the lamps will be illuminated or extinguished by the turning on or off of the current at the generating station, it appears to me that full advantage could be taken of all times of brilliant moonlight, thus saving electric current.

With regard to the quotations made by the electric light company, I find that for the St. Pancras electric lighting it has been estimated that the cost of lighting and maintaining a 1,200-c.p. lamp would be 2d. per lamp per hour, or a cost per annum for 3,900 hours of £32. 10s.

This estimate of cost is borne out by the experience of places in which electric lighting has been carried out in a thoroughly efficient manner.

A letter was read from the solicitor to the electric lighting company submitting an alternative scheme and an estimate for public lighting for the same area. The principal feature of the scheme is a combination of the arc and incandescent systems of lighting; each lamppost will support one arc and one incandescent light. Up till about 11 o'clock the arc lamps will be lighted, and at that hour the incandescent lamps will be lighted and the arc lamps shut off. This proposal appears to offer the advantages of a largely increased amount of lighting during the earlier hours of night, and during the remainder of the night nearly the same as the lamps at present in use afford. The following is the estimate for public lighting as an alternative scheme to the estimate already sent in to the Highways Committee:

Price per lamp per annum for 1,200-c.p. lamps burning up till 11 p.m., from 11 p.m. 16-c.p. lamps—3,900 hours' lighting per annum if contract is given now, so that the public lighting mains can be put in at the same time as the private mains:

	If Corporation find lampposts. £ s. d.		If company find lampposts. £ s. d.
30 lamps, seven years' contract...	22 14 0	...	24 0 0
60 " " " " ...	21 15 0	...	23 0 0
90 " " " " ...	21 0 0	...	22 5 0
30 lamps, five years' contract...	24 10 0	...	26 0 0
60 " " " " ...	23 10 0	...	25 0 0
90 " " " " ..	22 10 0	...	24 0 0

COMPANIES' MEETINGS.

EASTERN TELEGRAPH COMPANY.

Report of the Directors for the half-year ended September 30, 1891, presented to the thirty-ninth half-yearly ordinary general meeting held at Winchester House on Thursday.

The Directors submit the accounts and balance-sheet for the six months ended September 30, 1891. The revenue for the period amounted to £354,939. 5s. 4d., from which are deducted £97,130. 15s. 1d. for the ordinary expenses, and £47,047. 18s. 1d. for expenditure relating to repairs and renewals of cables, etc., during the half-year. After providing £4,816. 5s. for income tax, there remains a balance of £205,944. 7s. 2d., to which is added £313. 15s. 9d. brought from the preceding half-year, making a total available balance of £206,258. 2s. 11d. From this balance there have been paid :

Interest on debentures and debenture stock	£28,274 12 10
Dividend on preference shares	20,474 3 0
Two interim dividends of 2s. 6d. per share each on ordinary shares	100,000 0 0
	£148,748 15 10

leaving a balance of £57,509. 7s. 1d., which is carried forward to the next account. The revenue includes £33,398. 18s. 5d., dividends for the half-year upon the Company's shares in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies. The traffic over our whole system is satisfactory, and the revenue derived from Australian telegrams since the reduction of tariff is developing favourably. In accordance with the provisions of the articles of association, two of the directors, Sir A. J. Leppoc Cappel, K.C.I E., and Lord Sackville A. Cecil, retire by rotation at this meeting, and, being eligible, offer themselves for re-election. The auditors, Mr. Henry Dever, and Messrs. Welton, Jones, and Co., retire, and offer themselves for re-election.

Sir John Pender, K.C.M.G., chairman, presided at the meeting.

Before proceeding to the business before the meeting, the **Chairman** referred in sympathetic terms to the dark shadow which had fallen on the Royal Family through the death of the Duke of Clarence, and said that the news had been rapidly communicated to the vast Empire owned by this country through the medium of that Company's lines. Turning to the accounts, he said that their message receipts for the half-year ended September 31 last amounted to £321,135, as against £318,728 for the corresponding period of the previous year, an increase of £2,407. Dividends from their investments showed a decrease of £56. Interest and transfer fees had fallen off £285. The gross revenue was £354,939, as against £352,875, an increase of £2,066. The reduction of rates for European telegrams, which came into operation on July 1st last, he was glad to say had nearly been recouped, thus showing that there was considerable vitality in their business. Included in the accounts was the loss on five months' reduced tariffs to Australia. The reduction was still in force, and they had only had eight months' experience of it. At the end of the 12 months he thought they would be able to make a very satisfactory report on this head. They had already recouped some of the smaller losses by increased traffics in other directions than Australia. They were, on the whole, very well satisfied with the result of the conference which was held about 12 months ago. He was hopeful that a considerable portion of the loss on the Australian traffic up to the end of September, would be made up by increased receipts before the end of the financial year. The total expenditure for the half-year under review amounted to £97,130, as against £91,793, an increase of £5,407. Included in these figures was, however, the item for special repairs at Alexandria and Port Said. The amount carried to maintenance and ships' reserve fund was £4,000, as against £2,500. The working expenses showed an increase of £4,062. The amount paid for use of patents showed a decrease of £661, which was a permanent reduction, owing to some of the patents used by them having expired. Cable renewals and repairs showed an increase of £15,570. In 1890 this amount was exceptionally light, owing to their ships being hired by other companies. They had laid in 129 knots of new cable, the cost of which was included in the figures for the half-year. They carried forward £57,509, against £78,196, or a decrease of £20,666, but it must be remembered that the half-year ended September, 1890, was, as regarded ships' expenditure, an exceptionally favourable one. He would call their attention to the important fact that notwithstanding the large additions to their cable system during the last six years, the capital expenditure under this head had remained since 1885 at practically the same figure, in spite of the fact that they had laid over 7,000 miles of new cable during that period. This half-year they had applied from the reserve fund the sum of £105,110 in reduction of capital expenditure. About 11 years ago shareholders were good enough to sanction what was then called an insurance fund. A few months ago when he was addressing the Eastern Extension Telegraph Company, he drew the attention of the shareholders to an amended system which the Board were desirous of introducing, and which at the present time was in the hands of the actuaries. Probably youths were, as far as fingers were concerned, better for telegraphic work than older men. If they were to get good people, they must hold out to them some little benefit at the end of their arduous life. They thought to encourage thrift and economy on the part of their employés by meeting them and adding to the sum they might save, so that they might retire with a competency at the end of their service. Great confidence had to be placed in the men who worked their business, and they must be rather above the ordinary class, well-educated, well-connected men, who had some feeling of respect for their name and position. They had also to bear in mind that a great deal of their business was conducted in distant countries and tropical climates, and never in very pleasant places, because they had to have the bulk of their staff near to the place where the cables were landed. Consequently, their employés led an isolated life, and one which did not, he thought, tend very much to health. Therefore, they should be just and generous to these young fellows who embarked with them, and were in touch with them through the course of their working life. These remarks having been received with evident approval, the Chairman said he was glad they approved of the scheme, of which he could not give them the details, as these were being worked out most carefully. Their business was thriving. It was carrying out what he always told them, that every day that they lived telegraphy became a greater necessity. The world could not move without it, and as the world grew so must telegraphy. That Company was at the head of it. They still had some cables to duplicate, and some money yet to expend, but they took care before they spent the money to see where it would come from. Above all things, they were most desirous not to overburden themselves with capital. When they took into consideration the reduced value of money, and the fact that they still maintained their high rate of dividend, he thought the shareholders would be satisfied that their investment was good and sound. It was believed to be so by the whole commercial community of this and other countries. Taking the last two years and looking at the convulsions which had shaken the proudest houses to their foundations, when they saw the great depression that had followed in commerce, and when they saw the stock of the Eastern and Eastern Extension Companies standing higher than at any period of their existence, he could not offer better evidence of belief in their property. Moreover, when they found that their 4 per cent. debentures were at the present moment at 108 to 109—that was further evidence, that as debentures and as an investment their property ranked probably in the first class of investments. He moved the adoption of the report and accounts.

The **Marquis of Tweeddale** seconded.

Several shareholders spoke with pleasure of the scheme for an employés' superannuation fund, and hoped the older men would not be forgotten. In reply to questions,

The **Chairman** said that they were not forgetting the old men. As to all their cables being in working order, they were above the average in this respect. The Company was rarely without a broken cable, but owing to their system being duplicated, the public knew very little about such matters. A very important break had taken place in the South African cable the other day, and had they not had their ships in order to attend to it at once the work might have taken two months—as it was, the cable was repaired in five days. They repaired their own cables, and some of other people's too. They never allowed their ships to lie idle if they could help it, and they never lost an opportunity of making them earn the nimble penny. Last half-year (1890) they earned outside of their own companies, by means of their ships, £22,000, and the year before, £15,000.

The resolution was then put, and carried unanimously ; as also were motions re-electing Sir A. J. Leppoc Cappel and Lord Sackville A. Cecil, directors, and Messrs. Henry Dever, and Welton, Jones, and Co., auditors.

A vote of thanks to the Chairman closed the proceedings.

COMPANIES' REPORTS.

DIRECT UNITED STATES CABLE COMPANY.

The report of the Company for the six months ended Dec. 31 shows that the half-year's revenue, after deducting out payments, amounted to £45,402, against £43,346. The working and other expenses for the same period, including income tax, but exclusive of cost of repairs of cable, amounted to £17,672, leaving a balance of £27,729 as the net profit, making, with £3,502 brought forward, a total of £31,231. For the corresponding period of 1890 the working expenses and other payments amounted to £17,555. Interim dividends of 3s. 6d. per share for the quarter ended September 30, 1891 (paid October 24, 1891), and of 3s. 6d. per share for the quarter ended December 31, 1891 (payable Jan. 23, 1892), together amounting to £21,248, have been declared, and after setting aside £5,000 to the reserve fund account, the balance of £4,982 on the revenue account has been carried forward.

NEW COMPANIES REGISTERED.

Electric Fittings, Hiring, and Maintenance Company, Limited.—Registered by Messrs. Ashurst, Morris, Crisp, and Co., 17, Throgmorton-avenue, E.C., with a capital of £200,500, divided into 40,000 ordinary shares and 500 founders' shares of £5 and £1 respectively. The holders of the founders shares may, at any time after such shares are fully paid,

by a resolution passed at a meeting of such holders, determine that each founders' share shall be subdivided into founders' shares of such smaller amount as the meeting may determine, and thereupon the founders' shares shall be subdivided accordingly. As to the sum set apart out of the net profits of the company as a reserve fund, one-half thereof shall belong to the holders of the founders' shares, the other half to the holders of the ordinary shares, and the balance of the net profits shall be divided into two equal parts, one of which shall belong to the holders of the founders' shares, and the other half to the holders of the ordinary shares, and shall be divided among them in proportion to the amounts paid upon the ordinary and founders' shares respectively. The objects of the Company are to establish and maintain cables, wires, lines, accumulators, lamps, works, and fittings of every description for the generation, distribution, supply, accumulation, and employment of electricity; and to carry on business as electricians, generators and suppliers of electricity, mechanical engineers, manufacturers of and dealers in all kinds of apparatus therefor, as iron, brass, and other metal founders and fitters and metal workers; to effect insurances against fire or accidents arising from the employment of electricity. The first subscribers are:

	Shares.
A. Armstrong, The Albany, Piccadilly, W.	1
B. H. Martindale, Bickley, Kent	1
W. Crookes, F.R.S., 7, Kensington Park-gardens, W.	1
F. R. Reeves, Settle-heath, Potter's Bar	1
A. Palliser, jun., 21, Lime-street	1
H. Fleet, 4, Hayworth-road, Clapton	1
J. W. Fricker, 14, Addison-grove, Croydon	1

There shall not be less than three nor more than seven Directors; the first are to be nominated by the signatories to the memorandum of association. Qualification: £200. Remuneration: Chairman, £400; deputy-chairman, £300; and ordinary directors, £200 per annum each. An additional sum, equal to 5 per cent. on the net profits of the Company after payment of 7 per cent. dividend, shall be divided amongst them as they shall determine.

BUSINESS NOTES.

Dividend.—The Globe Telegraph and Trust Company announce interim dividends of 3s. per preference share and 1s. 6d. per ordinary share.

Cable Repaired.—The Eastern Extension Telegraph Company announce that their Hong Kong-Bolinao cable is now repaired, and telegrams can therefore be accepted for transmission to Manilla as usual.

City and South London Railway.—The receipts for the week ending 10th inst. were £858, against £748 for the corresponding period of last year, showing an increase of £110, and a decrease of £20 as compared with the week ending Jan. 3.

PROVISIONAL PATENTS, 1892.

JANUARY 4.

106. **Improvements in electric switches.** Wilson Henry Sturge, 12, Cherry-street, Birmingham. (Complete specification.)

109. **Improvements in telephone exchange systems.** Abner Mulholland Rosebrugh, 107, Mutual-street, Toronto, Canada.

110. **Improvements in generating and distributing electrical energy.** Rankin Kennedy, Carntyne Electric Works, Shettleston, Glasgow.

111. **Improvements in distributing and converting alternating electric currents, and in apparatus therefor.** Rankin Kennedy, Carntyne Electric Works, Shettleston, Glasgow.

152. **Improvements in vulcanising the insulating covering of electric conductors.** George Gatton Melhuish Harding-ham, 191, Fleet-street, London. (John Joseph Charles Smith, United States.)

JANUARY 5.

177. **Improvements in electric drop light.** Gwynne Ernest Painter, 11, Wellington-street, Strand, London. (Complete specification.)

207. **An electric regulator.** Edwin John Houghton and William White, 28, Southampton-buildings, London.

JANUARY 6.

253. **Improvements in magnetic apparatus.** Walter Thomas Goolden and Sydney Evershed, Woodfield Works, Harrow-road, London.

259. **A method of utilising electrical energy for the heating of water and other liquids.** Arnold Beaumont Woakes, 78, Harley-street, London.

278. **A wall contact and plug for electrical conductors.** William White and Edwin Percival Allam, 28, Southampton-buildings, London. (Complete specification.)

310. **Improvements in or relating to joints and attachments for concentric armoured electric conductors, and the methods of making the same.** Joseph Devonport Finney Andrews, 41, Parliament-street, Westminster, London.

JANUARY 7.

334. **Improved form of a dry galvanic element.** Henry Nehmer, 4, Grafton-street, Gower-street, London.

355. **Improvements in or relating to the electro-deposition of tin upon metals.** Edwin Charles Furby, 19, Southampton-buildings, London.

359. **An improvement in dynamo-electric machines.** Siemens Bros. and Co., Limited, John Nebel, and William Abraham Collings, 28, Southampton-buildings, London.

360. **Appliance for equalising the loads of the several conductors of rotary-phase current installations.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Messrs. Siemens and Halske, Germany.)

372. **Improvements in soldering, melting, and coating metals by the aid of electricity.** Nicholas Benardos, 24, Southampton-buildings, London.

JANUARY 8.

406. **Improvements connected with electric motors and electric elevator apparatus.** The American Elevator Company (Incorporated), 55, Chancery-lane, London. (Otis Bros. and Co., United States.) (Complete specification.)

407. **Improvements in liquid electrodes.** Edmond Savary d'Odiardi, 55, Cornwall-gardens, London.

408. **Improvements in electro-inhalers.** Edmond Savary d'Odiardi, 55, Cornwall-gardens, London.

409. **Improvements in the electric static sprays.** Edmond Savary d'Odiardi, 55, Cornwall-gardens, London.

410. **Improvements in pneumo-dynamometers.** Edmond Savary d'Odiardi, 55, Cornwall-gardens, London.

411. **Magneto-voltaic electrode.** Edmond Savary d'Odiardi, 55, Cornwall-gardens, London.

JANUARY 9.

475. **Improvements in apparatus for testing insulation electric meters and alternating-current motors.** James Swinburne, Broom Hall Works, Teddington, Middlesex.

486. **Improved variable resistances for electrical purposes.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.

487. **Improvements in means or apparatus for producing decorative, advertising, or other effects by the aid of electricity.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.

491. **Improvements in and relating to underground conduits for electric wires.** Carl Axel Wilhelm Hultman, 18, Buckingham-street, Strand, London.

495. **An improved electric battery electrolyte.** George Henry Robertson, 47, Lincoln's-inn-fields, London.

499. **A new or improved dynamotor or continuous-current transformer, and method of winding the field magnets of such.** Francis Murray Newton and Tom Hawkins, Norfolk House, Norfolk-street, London.

SPECIFICATIONS PUBLISHED.

1885.

12984* **Working metals by electric currents.** De Benardos and Olszewski. (Amended.) 1s. 3d.

1890.

20838. **Dry element for electrical purposes.** Birkbeck. (Henrichsen.) 6d.

21031. **Secondary batteries.** Davies. 1s. 6d.

1891.

1046. **Prepaid telephonic messages.** Gould and Gottschalk. 8d.

1639. **Condensers for electric currents.** Swinburne. 4d.

1680. **Transmitting electric currents.** Tavernier. 8d.

4554. **Armatures for electrical machinery.** Redfern. (Lahmeyer and Co.) 8d.

4579. **Electric cigar lighters, etc.** Binswanger and Smeeton. 6d.

19901. **Welding metals electrically.** Thompson. (Coffin.) 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{3}{8}$
— Pref.	—	$2\frac{3}{8}$
India Rubber, Gutta Percha & Telegraph Co.	10	$19\frac{1}{2}$
House-to-House	5	$5\frac{1}{2}$
Metropolitan Electric Supply	—	10
London Electric Supply	5	$1\frac{3}{8}$
Swan United	$3\frac{1}{2}$	$4\frac{1}{2}$
St. James'	—	$8\frac{7}{8}$
National Telephone	5	$4\frac{1}{2}$
Electric Construction	10	$6\frac{3}{8}$
Westminster Electric	—	$6\frac{5}{8}$
Liverpool Electric Supply	5	$5\frac{1}{8}$
	3	$2\frac{1}{8}$

NOTES.

Leith Docks.—A committee are considering the proposal to introduce electric light at Leith Docks.

Hawick.—Messrs. Mavor and Coulson are lighting a portion of the town of Hawick on contract as an experiment.

Fareham.—The Fareham Local Board have decided not to oppose the local company's application for a provisional order.

Leeds Electric Tramway.—Over 100,000 persons have been carried on the Roundhay Park-road since the opening.

Dessau.—At the Dessau central station a 120-h.p. Otto gas engine driving a Fritsche dynamo is used, running at 150 revolutions a minute.

Woolwich.—The undertakers under the Woolwich electric lighting order have applied for six months extension of time for depositing the £1,000 required.

Newspaper Lighting.—The *Daily Chronicle* have now their offices lighted by electric light. The installation was carried out by Messrs. Paterson and Cooper.

Average Hours of Lighting.—At Darmstadt the average duration of lighting for an incandescent lamp is 300 hours, at Elberfeld 700 hours, at Berlin 1,000 hours a year.

Electrical Portraits.—A speaking likeness of Dr. Silvanus P. Thompson appears in the *Electrical World*, N.Y., for Jan. 9, with a very appreciatory account of his scientific work.

Yorkshire College.—The first of a series of free lectures in the People's Hall connected with the Yorkshire College, Leeds, has been given by Prof. Stroud, D.Sc., on "The Telephone."

Electric-Coloured Boy.—During a thunderstorm in Maine, says a recent paragraph, the skin of a boy who was struck by lightning turned to a dark purple, and has remained so ever since!

Vetoing the Trolley.—The Mayor of Brooklyn, U.S., has vetoed the proposed scheme for the introduction of the trolley into that fashionable suburb of New York. It is hoped to get his veto upset.

Personal.—The Queen has been pleased to approve the appointment of Lord Rayleigh to be Lord-Lieutenant and Custos Rotulorum of the county of Essex, in the room of Lord Carlingford, resigned.

Electric Railways in France.—The contract for establishment of an electric railway between Veyrier and Monnetier-Mornex (Haute Savoy) has been entrusted to MM. de Meuron et Cuénod.

Utilising Niagara.—It is expected that the first contract to be entered into by the company which is to utilise the water power of Niagara, will be for the delivery of power to light the city of Buffalo.

Electric Tanning.—We have received a pamphlet with opinions of various authorities on the Worms et Balé process of electric tanning, published by M. A. Zwierzchowski, 32, rue Etienne-Marcel, Paris.

Institution.—The inaugural address by Prof. Ayrton, F.R.S., president of the Institution of Electrical Engineers, has, by reason of the lamented death of the Duke of Clarence, been postponed till the 28th inst.

Yarmouth.—Upon the statement by Mr. J. Harry Palmer at the Yarmouth Town Council, that electric light would cost twice as much as gas for the public lighting, the question was referred back to the committee.

Hammersmith.—The Hammersmith Vestry, after two hours' debate, have given their consent to the provisional order for the electric lighting of the district by the Putney and Hammersmith Electric Lighting Company.

City and South London.—We understand that a meeting of the shareholders of the South London Electric Railway will be held shortly to consider the question of the immediate extension of the railway to Islington.

Cleckheaton Town Hall.—The formal opening of Cleckheaton Town Hall will take place on February 10th, and the electric light, obtained from a 14-h.p. gas engine, has been installed, and will be used on the occasion.

Battersea.—A special committee of the Battersea Vestry is considering the question of electric lighting, and the Board of Trade has been asked to defer decision on applications for provisional orders until the matter has been dealt with by the Vestry.

Mutual Telephones.—We have received the January list of subscribers to the Mutual Telephone Company, of Manchester, which indicates the continued energy and increasing prosperity of the company. The list already contains about 900 names.

Royal Society.—At the Royal Society on Thursday papers were read by Major Cardew, "On a Differential Electrostatic Method of Measuring High Electrical Resistances"; Prof. Schuster, F.R.S., and A. W. Crossley, "On the Electrolysis of Silver Nitrate in Vacuo."

Moffat (N.B.)—The Moffat Municipal Authority had the question of lighting the town by electricity before them at their last meeting. The clerk was directed to enquire upon what terms Mr. J. J. Hope-Johnstone, of Annandale, will grant the dyemill water power for that purpose.

Whitehall Club.—A dinner of the electrical engineers who are members of the Whitehall Club is to be held on Friday, the 29th inst., at the club. It is hoped that Mr. Tesla will be present, unless the postponement of his lecture from the 28th inst. to February 3 delays his arrival in London.

Dewsbury.—At the meeting of the Dewsbury Town Council held on Friday, the Gas Committee reported that they had sent out circulars to 221 persons and firms, enquiring if they would take the electric light in case the Corporation laid down a public installation, and only nine had given assent.

Jarrow.—At the monthly meeting of the Jarrow Town Council on the 13th inst., it was recommended that the town clerk be instructed to communicate with three or four of the principal electric lighting companies in the district inviting them to apply for permission to supply the borough with the electric light.

Proposed Electric Railway in Paris.—The Prefect of the Seine, says Dalziel, has received a proposal from a firm in London for a concession to construct an underground electric railway in Paris on an entirely new system. The subway would extend over 25 kilometres, and have five branches, connecting all the chief points of the capital.

London Electric Railways.—Among the private Bills which passed the examiners last week was one for the extension of the City and South London Electric Railway to Islington. In respect to the proposed Waterloo and Royal Exchange Railway there was no appearance on behalf of the promoters, and the Bill was struck out of the list.

Taunton.—At the monthly meeting of the Taunton Town Council on the 13th inst., the proposed acquirement of the properties of the gas and electric light companies was discussed at some length, and ultimately the matter was referred to the Streets and Highways Committee and the Finance Committee, who will be merged for the consideration of the subject.

Nottingham.—The celebrated Castle Museum at Nottingham is to be lighted by electric light. Mr. G. H. Wallis, the curator, will show the rooms. Persons desirous of tendering may send in sealed tenders and specifications, to be opened at the next meeting of the Castle Museum Committee. Further particulars of the curator, or of Mr. Samuel G. Johnson, town clerk.

Lynton and Lynmouth.—The electric light is rapidly becoming appreciated in Lynton and Lynmouth. Mr. H. H. Benn, the proprietor of the works, has just installed the light in the Devon and Cornwall Bank, as well as the manager's residence—the first private house in the neighbourhood in which the electric light has been adopted, and the result is found very satisfactory.

St. Helens.—A Local Government Board enquiry has been conducted here by General Phipps Carey, partly relative to the electric lighting of the Town Hall, which is greatly desired. The town clerk explained that there will be 335 16-c.p. lamps throughout the building, the engines and dynamos being regarded as a temporary arrangement until the whole town has the electric light.

Liverpool.—The Watch Committee of the Liverpool Corporation on Monday considered a memorial from 448 commercial firms in the city using the electric light, praying the Corporation to consent to the application of the Liverpool Electric Supply Company to extend the term of purchase in the city to 42 years. The committee decided that they could not grant the application in its present form.

Lauffen-Frankfort Plant.—Recent statistics of the figures obtained with the Frankfort transmission plant show that the commercial efficiency was over 72 per cent. The cost per effective horse-power was about £56. 10s., the distance of transmission being, as will be remembered, 110 miles. It was half expected that there might be extraordinary losses not deducible from Ohm's law, but the results show that this was not the case.

Shoreditch.—A communication from the Gas Light and Coke Company was read at the last meeting of the Shoreditch Guardian Board, stating that the price of gas would be raised to 3s. 1d. per 1,000ft., an increase of 4d. per 1,000ft. It was suggested that Mr. Joyce, the engineer, should be consulted as to the employment of electric light. The question was referred to committee in order that they might consult with the engineer.

Waterford.—Tenders are required for the public lighting of part of the city at present lighted by electricity, and also in the alternative for the public lighting of the entire city, either by gas or electricity, for periods of two, five, or ten years, from September 1, for the Public Lighting Committee. Tenders to be sent to Mr. Joseph W. Howard, town clerk, by February 1. All information can be obtained at the office of Mr. M. J. Fleming, borough surveyor, The Mall, Waterford.

Tesla's Experiments.—During the past six months Mr. Tesla has been hard at work developing the experiments he gave before the American Institute of Electrical Engineers, in the direction of important practical applications. Some of the points of his work are already embodied in patents on incandescent lighting and on condensers. Many of the practical difficulties have already been overcome, and it is hoped that ere long the results may be seen in commercial use.

"Evil (Telephonic) Communications Corrupt."—At Dundee the National Telephone Company sued John Milne and Son for £8. 10s., rental of telephone. Mr. Urquhart, for his clients, stated that inefficient service was given at the time of the day most required, and urged that half the profanity amonst the Cowgate merchants was due to the bad telephone service. It was by no means improving to their morals. The case is being continued.

The Old Students' Association.—In accordance with the announcement made at the last annual dinner Mr. Reginald J. Jones has been obliged, owing to pressure of professional work, to resign the hon. secretaryship of the Old Students' Association. Mr. E. B. Vignoles has been appointed as hon. secretary and hon. treasurer, and Mr. A. E. Ruddock as assistant hon. secretary. All correspondence and subscriptions should therefore in future be sent to Mr. E. B. Vignoles, 28, Lanhill-road, Elgin-avenue, W.

Electric Leakage through Snow Contact.—Snow has fallen so heavily in the districts of Gex, Nantua, and Bugey, says Dalziel's correspondent at Lyons, that telegraphic communication has been suspended. Curious phenomena have occurred at Culos, where electric light wires have been so heavily covered with snow that a kind of partial contact has been established, and a series of lightning flashes between the different wires has been going on for some time, to the great delight of admiring crowds.

Cantor Lectures.—Before the Society of Arts, on Monday next, January 25, Prof. Forbes, F.R.S., will deliver the first of his series of the Cantor lectures on "Developments of Electrical Distribution." Lecture I. will deal with low-pressure supply; comparison between 1885 and 1892; central station *v.* isolated plants; electricity *v.* gas; cost of feeders and mains; management of feeders; use of recording apparatus; house wiring; three and five-wire systems; use of motor-dynamos as compensators; and use of batteries.

Contraction of Copper Mains.—A new cause of interference of the electric light supply has been found in the action of frost. A drop of some 20deg. took place a little while ago, it will be remembered, and at Bath the light failed at this time, due, Mr. Massingham states, to contraction and expansion in the joints of the main. The Electric Light Committee of the Bath Town Council is to make an exhaustive report upon the subject. It would be interesting to hear if any other companies have experienced difficulties from the same cause.

Electric Canal Boats.—Electric motors for canal boat propulsion has been often proposed with many variants in design. A likely scheme is that described in the N. Y. *Electrical Engineer*, as proposed by Mr. Otto Büsser. A stationary cable is laid along the bottom of the canal. This cable passes over sheaves in the canal boat, driven by a motor, the current for which is supplied by trolley wires in the usual way. A peculiar feature is that the installation is transportable, being fitted on the gunwales of the boat as it enters the canal, and removed at the further end.

Glasgow Tramways.—At last week's Glasgow Town Council meeting, Bailie Paton intimated that the Tramway Committee had found that the offer of the General Electric Traction Company would enable the Corporation to work the tramways at 1d. per mile less than it could be done by animal power. This would be a saving of £18,000 a year. It was proposed at the end of the lease, two and a half years hence, to begin to use electricity for some por-

tions of the line. The committee were negotiating with the tramway company for the whole or part of the stabling and plant.

Factory Lighting.—The New York Mills, in Nidderdale, which about three years ago were purchased by Messrs. Thomas Gill and Sons, twine manufacturers, and have since been rebuilt, are now lighted by the electric light, the dynamo being worked by a turbine placed specially for the purpose, so that the mill machinery and the electric light may be worked independently of each other. The installation has been carried out by the Roper Engineering Company, of Bradford. This is the first instance of the electric light being brought into practical use in the district.

Fire Alarms at Chiswick.—The Chiswick Local Board met last week to consider and, if thought expedient, to accept tenders for the erection and maintenance of fire alarm posts, calls, etc. Tenders were opened as follows: Roxburgh and Co., with telphones £330, without £290; Messrs. Blenheim and Co., with, £379; Messrs. Spagnoletti and Crookes, with £415, without £365; Mr. F. E. Stuart, with £438. 17s., without £368. 17s.; and the Home Telephone Company, with £300, without £265. The Board decided that Dr. Diplock, as captain of the fire brigade, should consult with the surveyor on the tenders and report to the Board.

St. Pancras.—The arc lights at St. Pancras have been turned on in Tottenham Court-road to the satisfaction of the inhabitants and the members of the St. Pancras Vestry. The turning on took place on Friday, and on Saturday in the small hours, the Electricity Committee, attended by Prof. Robinson and Mr. Eccleston Gibb, made some experiments as to the comparative intensity of lighting of the electric light and the gas. The 12 Brockie-Pell arc lamps were found to give considerably more light than the 85 gas lamps, besides rendering unnecessary some of the gas lamps down the side streets. Euston-road, from Trinity Church to Euston-square, has been similarly lighted since Tuesday.

Chester.—At the monthly meeting of the Chester Town Council, on the 13th inst., Alderman William Johnson moved, and Mr. J. J. Cunnah seconded, the adoption of a recommendation of the Watch Committee that a sum not exceeding £20,000 be voted for providing a first installation of the electric light for Chester. Alderman H. T. Brown opposed the motion, on the ground that if the matter were taken up by the Corporation all the risk and loss would fall upon the citizens, and they should be taxing the whole town for the purpose of making up the deficiency in the working expenses for the benefit of a few individuals. This was evidently not the feeling of the Council, as after considerable discussion the motion was carried by a large majority.

Mining Engineers.—It is proposed to establish a London Institute of Mining Engineers, having for its objects the advancement and encouragement of the sciences of mining, metallurgy, engineering, and their allied industries, the interchange of opinions by the reading of communications from members and others, and by discussions at general meetings, upon improvements in mining, metallurgy, engineering, and their allied industries, and the publication of original communications, discussions, and other papers connected with the objects of the institution. It is suggested that the institute should be lodged in suitable offices, which might also be jointly occupied by the Federated Institution of Mining Engineers. A spacious hall for meetings and for the formation of a mining library is also contemplated.

Medical Electricity.—The Institute of Medical Electricity has done useful work in introducing scientific electricity to the medical profession, and the earnest work of Mr. H. Newman Lawrence and Dr. Harries will certainly not be lost. But we suppose the institution did not pay as well as was expected, for it has lately been wound up voluntarily. Mr. H. Newman Lawrence is carrying on the same work upon his own account, and has opened rooms at 36, St. Martin's-lane, where he is intending to continue to treat patients by electricity and massage. Mr. Lawrence has our best wishes, as although the subject is difficult ground, his long work in attempting to apply electricity scientifically to the relief of paralysis, the "cataphoric medication," or dosing by electro-deposition of drugs, and other matters, have helped to pave the way to better use of electricity in medicine.

Edison Electric Railway.—The announcement of a novel and practical system of electric railway without overhead trolley wires by Mr. Edison some time back stopped, it appears, very many contracts for the trolley system being completed, the street railway companies in many instances preferring to wait until the value of the Edison system was demonstrated. Mr. Edison has issued a proclamation which will at any rate allay the fears of some of the other street railway engineers. He has authorised the statement that the new system is designed exclusively for roads of heavy traffic, in large cities, where the expense of a fresh line is warranted by the traffic, and where the overhead trolley is not admitted. "The new system," the statement continues, "will not be applicable, in a commercial sense, to long roads running less than 50 cars simultaneously. It must, therefore, be understood that outside of the large cities the best system that can be advocated is the trolley."

Inverness.—A committee meeting of Police Commissioners was held on Monday to consider the question of introducing electricity or extending the gas works by an expenditure of £10,000. The gas manager recommended that his scheme be modified to the extent of £2,300, but the convener of the Lighting Committee moved that the original scheme be adhered to in view of the improbability of the electric light being introduced. A motion in favour of delay to allow further discussion of the electric light scheme was moved by Mr. James Cook. Mr. Wm. Smith read a letter from a firm of London electric lighting engineers to the effect that the idea of generating the light at the Falls of Foyers was out of the question for a town of the size of Inverness, as it would lead to an expense of about £50,000; and Mr. Smith argued that this was the only scheme which could be entertained, as the taking of water from the Caledonian Canal would lessen the volume of the River Ness, and lead to litigation with fishing proprietors. After discussion, it was finally agreed to proceed at once with the extension of the gas works, provided the Police Commissioners are agreeable.

National Telephones.—A meeting of the Executive Council of the County Councils Association was held on the 13th inst. at the Guildhall, Westminster, Lord Thring in the chair. Among those present were Lord Baring, Baron Dimsdale, M.P., Sir John Dorington, M.P., Mr. Littler, Q.C., C.B., and representatives from Bedfordshire, Lancashire, Middlesex, Hertfordshire, Hampshire, Essex, Surrey, Monmouthshire, Lincolnshire, Northamptonshire, Gloucestershire, and Westmoreland. The Executive Council considered the private Bill which has been deposited in the Private Bill Office of the House of Commons for the purpose of affording "to the National Telephone Company, Limited, additional facilities for conducting the business of telephonic communication," and

resolved "That the attention of the Local Government Board and of the Board of Trade be called to the highly objectionable provisions contained in the National Telephone Company's Bill, and that it be suggested that the subjects contained in it ought to be provided for in a Bill introduced by a Government Department." It was arranged that the annual meeting should be held on the 17th of next month at the Guildhall, Westminster.

An Electrical Fog Bell.—The port of Ravenna in the Adriatic has recently, says the *Times*, been provided with a fog bell, the invention of the Abbé Ravaglia, worked by electricity. It is situated at the end of the mole leading into the harbour, and the current is conveyed to it from a battery in the lighthouse about a kilometre distant. The apparatus for striking the bell consists of a magneto-electric motor planted in the bell tower, and connected to a mechanical puller. When the current from the battery passes through the armature of the motor, the motion of the armature is caused to turn a disc having pins projecting from its border. These pins catch on the end of a pivoted lever as the disc revolves, and by raising one end of the lever depress the other, thereby pulling the bell chain and making the hammer strike the outer rim of the bell. A rapid series of strokes is the result, and the loud continuous note is heard for a long way. The battery employed is the constant form of Daniell, and a galvanometer is kept in the circuit to show that the current is of proper strength. A telephone circuit also enables the attendant at the lighthouse to hear the "drone" of the motor and thus know whether it is working at its proper speed. Such an apparatus is, under certain circumstances, cheaper, simpler, and more convenient than a steam syren or a bell actuated by the waves.

Pontypridd.—A deputation from the Pontypridd Chamber of Trade waited upon the Pontypridd Local Board last week for the purpose of bringing before the notice of the Board the lighting of the town, and urging upon them either to purchase the present gas works or to undertake the lighting of the town by electricity or some other illuminant. The deputation was introduced by Mr. H. S. Davies (president of the Chamber of Trade), who stated that in view of the ineffective lighting it would be desirable to take over the lighting themselves. Mr. Leyshon, chairman of the Board, said he was glad the deputation had waited upon them, as this would strengthen their hands. It was understood that the gas company intended to spend £2,000 on extensions. Councillor Roberts thought that partial lighting by gas and partial lighting by electricity would lead to difficulties. He agreed with the purchase of the gas works. Mr. Snape said the capital of the present company was not sufficient to meet the requirements of the district by properly enlarging the works. It was ultimately decided that the gas company should be written to and asked if they were prepared to treat with the Board for the sale of the works, and it was further decided to engage an expert to value the gas works. Perhaps, with further information before them, the Board would not be opposed to the introduction of electric light as well as gas. At any rate the present would seem a favourable opportunity for bring forward the subject.

Sunderland.—A special meeting of the Highways Committee of the Sunderland Corporation has been held to consider offers for lighting with electricity that part of the town comprised in the provisional order which was obtained by the Corporation in 1891. Applications had been invited by the Corporation from companies prepared to take over the powers, and two were received—viz., from the Brush Electric Supply Company and Messrs. Andrews and Co., London. The former proposed to take over the order with all its obligations on condition that the Corporation assisted them to form a local company, with arrangement for repurchase; that the public lighting should be given at such price as should be arranged hereafter; and that no concession of any kind be granted to any other company. Messrs. Andrews proposed to take over the area mentioned in the provisional order, to supply it with electricity for lighting purposes on the alternating-current high-pressure system at a uniform charge of 3¾d. per Board of Trade unit, and to pay the Corporation a rental of £100, together with a royalty according to the consumption. They required payment for the goodwill if at the end of 21 years the Corporation wished to acquire the concern. The terms of both offers were discussed, and it was ultimately agreed to submit the same to Mr. Shoolbred, who had previously been consulted by the committee with regard to the provisional order, and to await his report.

Walsall.—At the monthly meeting of the Walsall Town Council on Monday, a resolution was proposed by the Mayor, "That the Council carry out themselves their electric lighting order of 1890, and that they proceed to provide an electric lighting plant on the lines suggested in the report of Mr. Frederick Brown, A.I.E.E., at an estimated cost of £21,450, and that the Electric Lighting Sub-Committee be authorised to prepare and present for consideration plans and specifications of the proposed work, and a detailed estimate of the cost of the same." He said that they had to establish the light in the town, and the only question was whether it would pay. Mr. Brown held that with 2,000 lights of 16 c.p. each they would realise £1,266 a year profit on the expenditure of £21,000. He felt sure that this would be a step in the right direction, and that it was wise to keep the matter in their own hands. Birmingham certainly had not done their own electric lighting; but Birmingham did not always set a perfect example. Alderman Evans seconded. The Mayor stated that the streets at present proposed to supply were Digbeth, and Park, Bradford, Bridge, High, Darwall, Lester, and Goodall streets. Councillor Dean asked whether they would not at once include the centre of Bloxwich? Councillor Bowen suggested the centre of the Pleck as well, while the Mayor said that they thought it would be wise to deal with the centre of Walsall first. Alderman Lindop, in reply to Councillor Powell, said that the plant might be completed in about eight months.

City Lighting.—The directors of the City of London Electric Lighting Company, in announcing the issue of 9,848 ordinary shares at 5s. premium, give some information as to the progress of the City lighting. The two generating stations at Meredith's Wharf, Bankside, and at Wool Quay, Lower Thames-street, are both working. The supply of current has been commenced from each, and the erection of additional generating plant is being actively proceeded with. Queen Victoria-street, Gracechurch-street, King William-street, and Cornhill are already lighted, and the work is so far advanced that the lighting in many other of the main thoroughfares of the City will be commenced in a few weeks. In consequence of the exceptional facilities granted by the Commissioners of Sewers since their meeting of December 1 last, the opening up of the main thoroughfares has proceeded very rapidly, and the present rate of progress is about a mile a week. This will enable the company to reach the best paying districts of the City at an early date, and the earning of a substantial revenue will consequently be materially hastened. With reference to private lighting, they state that since the lighting of the Mansion House from the company's mains in December last the engineering staff has

been continuously employed in connecting the premises of further customers. Signed applications for about 13,000 lamps have been already received, and are being added to at the rate of 1,500 a week. Informal applications for a large additional number have also been made. With reference to revenue, an encouraging statement is made. For obvious reasons, they say, it is necessary when establishing an electric supply station to provide a staff out of proportion to the amount of current at first delivered. In spite of this drawback, however, Mr. David Cook, the company's recently-appointed manager, reports the revenue already being earned to be in excess of the current expenditure at the generating stations.

Accrington.—The Corporation of Accrington having obtained their provisional order for the supply of electric light, a scheme for the erection of a central station, with the laying of mains in the principal business thoroughfares, is now under consideration. The Council have issued a circular meanwhile to the inhabitants, in which they say: "Before establishing the central generating station, the Corporation is anxious to carefully ascertain what demand for the supply of electricity can be depended upon in the district in which the first mains are proposed to be laid, and as your premises are within that district will you please inform the Corporation whether you propose making use of the light and to what extent. The Corporation being desirous of affording information as to the probable cost of using the light, has consulted Mr. J. N. Shoolbred as to the price of the electric light in Accrington, as compared to the present price of gas. The price of the electricity to be supplied by the Corporation is limited by the provisional order not to exceed 8d. per unit. The illuminating value of a unit of electrical energy is about equal to that of 100 cubic feet of gas, so 10 units, with incandescent lamps of 16 c.p. each, will produce an amount of illumination about equal to 1,000 cubic feet of gas supplied by the company. This electrical energy, if supplied at 6d. per unit, is equivalent to gas at 5s. per thousand cubic feet. The cost of supply will, of course, vary with the demand—the greater the demand the less the Corporation will be able to supply the light at. To add to the cost of the light will be the meter rent at 10 per cent., as with gas meters, unless the consumer supplies his own meter. The consumer will, of course, provide his own internal fittings and lamps, and as regards these he is advised to make his own enquiries, the cost of same varying very much in the character of the fittings, the position and number of lights, and the internal arrangement of the premises to be lighted. It may, however, be stated that in the case of new buildings the internal fittings for the light have been found to cost about one-half that of gasfittings."

Unit Pole.—Mr. Chas. E. Emery made some sensible remarks with reference to unit pole and lines of force in the discussion on the recent paper on "Magnetic Reluctance," by Mr. A. E. Kennelly. "In investigating the formulæ for the construction of motors and dynamos," says Mr. Emery, "it becomes quite evident that 4π is nothing more or less than a simple arithmetical coefficient which, in this connection, has nothing to do with its customary significance as expressing the surface of a sphere of unit radius. It is thought that this should be emphasised by writing the figures instead of the symbol, or, for convenience of calculation, substituting a single special character, for instance *a*, for it, and stating its numerical value. The artificial conception that a line of force radiates from a unit of surface of a sphere of unit radius may be comprehended so far as the unit is concerned, but has not the slightest applicability in practical work. The conception causes great difficulties in the minds of students"—as well it may. The conception which we should like to see adopted, that unit pole is that produced by one line of force, on the other hand though interfering with the balanced theorisings of mathematicians, would lead at once to simple explanations of most of the ordinary phenomena of magnetism and induction. The metre itself, as Mr. Emery remarks, and we should do well to remember in these discussions, "is nothing more or less than the distance between two marks on gold plugs on a platinum bar," even as our own yard. He adds, "It must not be thought that the use of absolute measure in electrical formulæ for proportioning dynamos and motors secure absolute accuracy. There is apparently no numerical coefficient at the beginning of such formulæ which can be modified to suit the conditions, but allowances are necessarily made at another stage of the calculation, as the number of lines of exciting force must be 20 to 40 per cent. in excess of those used across the armature." He recommends the factor which Towle, engineer to the "Great Eastern," said should be embodied in every formula—K = common sense. There is a great deal in this, as every practical designer of dynamos well knows.

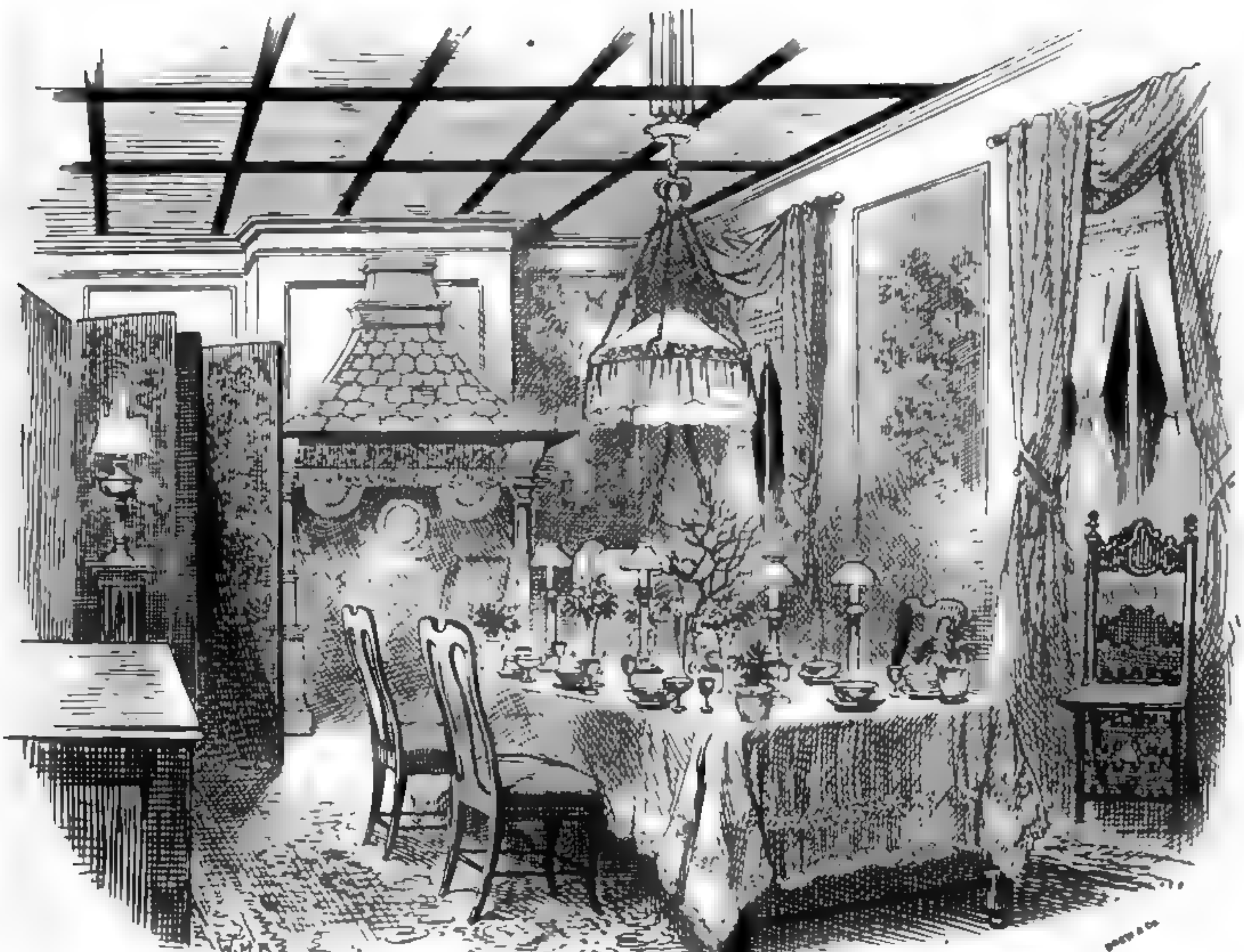
Rotary-Current Plant.—A complete "Drehstrom" plant is now being installed for experimental testing at Messrs. Greenwood and Batley's rooms in Albany-mansions, Victoria-street, and has already been visited by many electrical engineers. The plant has been brought over from the Allgemeine Company, of Berlin, by Mr. Henry Edmunds and Mr. Reckenzaun, and installed in the rooms placed at their disposal by Mr. Blackwell, of Messrs. Greenwood and Batley. It has already undergone some interesting tests at the hands of Mr. Kapp, and has been shown by him at his lecture to the Royal Engineers at Woolwich. The plant consists first of an ordinary continuous-current dynamo, driven as motor from the Westminster mains at 105 volts, the current after having entered the armature of this motor being taken off to ring collectors connected at points 180deg. from each other in the segments, this giving a three-phase current. The field magnets are excited by a separate wire from the mains, but the total current used, about 50 amperes, passes through a single ammeter. Both field and armature currents are controlled by resistances. The three-phase current is led first to a reversing switch, passing through the ammeter which registers one-third of the total current. This ammeter, when we visited the plant, showed 29 amperes. The voltage between any two of the three wires remains the same, and lamps can be lighted on any two of the wires. The pressure was 59 volts. The three-phase current passes to a small rotary-current dynamo having three collectors. In this particular specimen the current generates a rotating magnetic field in the armature, which, reacting on a laminated iron case surrounding it, rotates, and so drives another ordinary dynamo connected to the motor shaft. This dynamo lights 29 100-volt lamps. We understand that Mr. Kapp's tests showed the efficiency of the motor to be about 80 per cent. In the new form of motor which is being prepared, the rotating field will be induced in the stationary field magnet, and the armature will be a solid core dragged round by the rotary field. This form of rotary-current motor has the advantage of doing away with the need of collectors and brushes, the wires being connected direct to the motor. The motor starts under full load. The speed of rotation at full speed is not quite synchronous to that of the supply motor, but less a certain lag due to the mechanical friction. The plant is extremely interesting, as being the first installation of the "Drehstrom" motors in England.

THE CRYSTAL PALACE EXHIBITION.

The Exhibition is gradually approaching completion. Chaos is giving place to order, and in the machine department especially a vast amount of work has been done since our last issue. Almost all the stands have now machines in running order, and the variety of gas engines will prove a characteristic of the Exhibition. While, however, we may admire the diversity of this class of engines, and the eagerness to produce them shown since certain patents lapsed, the engineer will turn with greater admiration to some of the examples of steam engines at work. Messrs. Davey, Paxman, and Co. have finished the erection of the 250-h.p. engine driving Kapp's dynamo, and at the time of our visit it was running with great smoothness and without noise. Messrs. Easton and Anderson, too, are driving Prentice's dynamos with their engine. Crompton and Co. have a splendid specimen of Crossley's gas engine going. Siemens's are using Willans and Robinson's engines, and so on. Probably the Machine Room will be complete by the end of the month, when it will be well worth a careful examination. In the body of the building several stands are yet bare, some not even commenced, and in the galleries much still remains to be done by the art furnishers and decorators.

One of the characteristic features of this Exhibition will be found in the upholstering department. A variety of firms have furnished rooms with a special view to their being lighted by means of incandescent lamps. It has been remarked that visitors will probably prefer to wander among these luxuriously-furnished rooms rather than among the moving machinery in the Machine Room. It must be remembered, however, that if householders are to be induced to patronise the electric light, more will be done by showing ready-fitted suites of rooms than by showing dynamos; and it must also be remembered that the adoption of the light means the adoption of the dynamo. Hence we should all support the enterprise of those firms who have gone to the expense and trouble of showing how apt a means of illuminating handsomely-furnished and costly-decorated rooms is afforded by the incandescent lamp.

We have already referred more than once to the well-arranged exhibit of **Messrs. H. and J. Cooper,** designers and decorators, of 8 and 9, Great Pulteney-street, W., which will be found at Stand 203 in the South Gallery. Owing to the fact that the suite of rooms shown by this firm was complete down to the smallest detail on the opening day, we are able to give a description of them in our present issue. Later on we shall hope to publish some sketches, which will give an idea of the design and decoration of the different rooms.



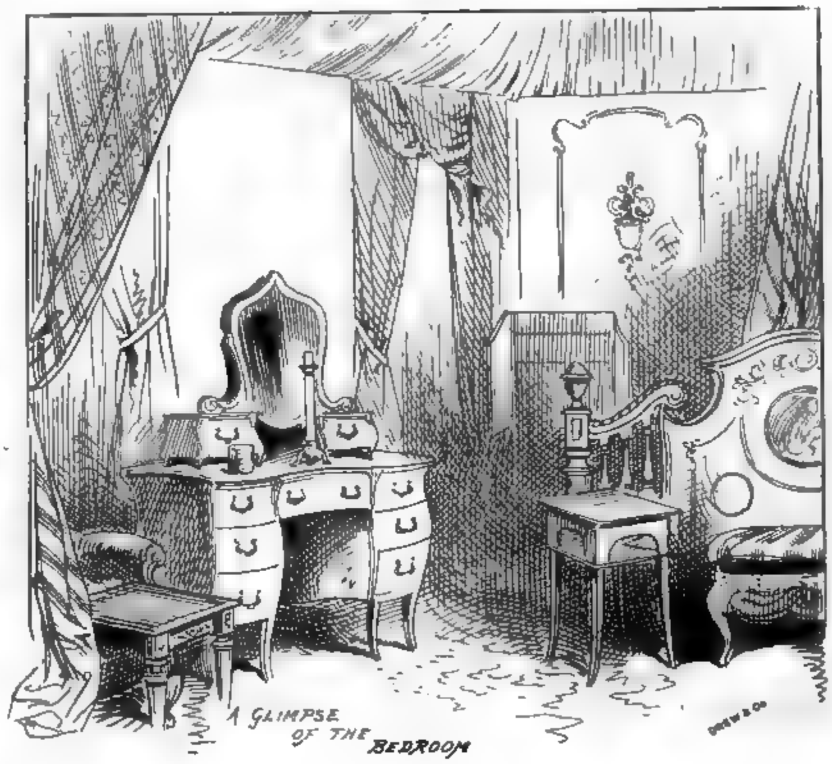
The Dining Room.—Messrs. Cooper's Exhibit.

Though the suite has been erected with great care and completeness of detail, the exigencies of space and position have, as in the case of a theatrical stage, made it necessary to play some tricks with actualities. So we enter through a handsome grilled screen of wrought iron, which is worthy of more than a cursory glance, and make our exit at the other end of the suite, through a draped archway, whose existence is easily blotted out by a slight effort of the imagination. The suite consists of a dining-room, boudoir and bedroom, each decorated and furnished in a different style. We will begin with the dining-room, the dimensions of which are 22ft. by 15ft. It is a handsomely furnished room with two delicately-draped windows overlooking the Winter Garden. The table in the centre is laid and looks provokingly tempting. At the end by which we have entered is the fireplace, arranged as an ingle-nook, of carved oak in the Early Renaissance style. In the recess of this nook are cosy seats covered with

Genoese velvet in Venetian design. Incandescent lamps in the corners give a mellow light, and with a bright fire on the hearth this would be just the place for building castles in the air, or for a *tête-à-tête* with some congenial spirit. The walls are panelled with pictures of the Flemish school, whilst the windows are flanked on either side by armour, which has a novel and striking effect. Near the ingle-nook is an old-fashioned armchair, a reproduction of the eighteenth-century style, and marvellously comfortable for bones of all ages. The chairs placed round the dining-table owe their design to the times of good Queen Anne, and are light and graceful in appearance. Opposite the fireplace are massive carved oak entrance doors, surmounted by a pediment carved with much spirit. The floor, of patent removable parquet, is covered with a fine Anatolian carpet. The table, which, as we have intimated above, is laid for dinner, is furnished with Venetian glass, and seasonably decorated with mistletoe. The centre-piece consists of a frosted branch of hawthorn with bird and, if we mistake not, nest also—which is not quite in accordance with the usual course of things natural. The table is lighted by candlesticks fitted with imitation candles carrying incandescent lamps, and by other lamps ranged round the room so as to light the pictures. Taken as a whole, when lighted, this room has an appearance of cosiness and warmth which draws frequent exclamations of delight from visitors. Everything is tasteful and harmonious, and the lights are judiciously placed so as to give a good effect without intruding themselves on the eye.

From the dining-room we pass into an Oriental boudoir, which will assuredly excite covetous feelings in the breast of many a fair visitor to the exhibition. Exactly opposite us as we enter is a plaster cast reproduction of an Arabian niche, such as is usually placed in Eastern mosques to denote the position of Mecca. This niche, with its gorgeous gilding, surmounts panels of rare old Persian tiles of antique colouring. To the left of the niche is a specially designed window in the Arabian style, the powerful colouring of which has been most harmoniously blended. In another corner are divan seats with a canopy of rich silk, upheld by inlaid Persian spears. The seats are covered with fine embroidery and provided with embroidered cushions. In the wall close by is a beautifully designed Arabian panel of very fine lattice work. A large wall panel of plate glass, overlaid with gilt palm fret, adds much to the beauty of the room. Beneath it is a seat in embroidered Moorish work, which is flanked by a pair of very fine Persian candlesticks of pierced brasswork, standing some 4ft. high. Near the canopied divan stands a coffee-table with a top consisting of one large circular Persian tile, the colouring of which is lovely. A second coffee-table of Damascus work, inlaid with mother-of-pearl and silver, stands in another corner of the room near the Mecca niche. The Cairene apron-piece of the room has a tented roof, in keeping with the Eastern character of the furniture and decorations. The boudoir is lighted from reproductions of antique Arabian vases hanging from the apron piece. The floor is covered with matting, over which are laid rugs and mats. In truth 'tis a room wherein to listen to the 1,001 nights, or whisper into sympathetic ears those soft nothings which mean so much—a room full of rich colour, and yet a room in which a tired mind and aching eyes might well find rest.

From the boudoir, a doorway, the soffits of which are supported by beautifully carved stalactite brackets, the whole being draped with gold silk gauze, leads to a bedroom, which may be termed an English rendering of the Louis Quinze style. From the exclamations escaping visitors of the fair sex on entering this room, we may take it that "lovely" and "exquisite" are the proper terms to apply to it. The principal decorations are in salmon and white. The ceiling consists of a large oval centre, hand-painted with cupids, after Boucher. From this centre-piece falls a silk draping which reaches to the top of the walls, somewhat after the manner of a tented roof in the French style. The bedstead is white with *carton pierre* decoration, the centre panel at the foot bearing hand-painted cupids in the same style as the ceiling centre-piece. The head is surmounted by a canopy nearly reaching to the ceiling, of salmon silk with overdrapery of white muslin. This canopy is caught up by two cupids, while a third tiny fellow flying in mid-air holds an incandescent lamp. The coverlet consists of a handsome piece of embroidery, bordered with plain figured silk. By the side of the bed stands a compact little writing-screen, available for the composition of those mysterious missives usually known as *billets doux*. When not used for writing it folds up into a screen. Messrs. Cooper have submitted one of these screens to the Princess of Wales. The dressing-table is of a novel and very elegant design, with bevelled mirror, also of uncommon design. The draperies of the windows consist of salmon silk, the valances of which are embellished by gold darts. The fireplace is in mahogany, with Bartolozzi engravings let into the panels, and fitted with a handsome pierced and chased brass fender. On the other side of the room is a special



A Corner of the Boudoir and Bedroom.—Messrs. Cooper's Exhibit.

fitment introduced by Messrs. Cooper, with the idea of doing away with much movable and bulky furniture in the shape of wardrobes, chests of drawers, and so on. The fitment contains wardrobe, drawers, shelves for books, etc. The frieze over the wardrobe is ornamented with hand-painted lunettes in the same style as the ceiling and the bedstead. The door leading out of the room is of mahogany, the two upper panels having Bartolozzi engravings with gilt mounts, and is surmounted by an overdoor with *carton pierre* decoration and more engravings. The door furniture is of pierced brass. In one corner stands an elegant easel, which the designers have named the "Princess Christian," after her Royal Highness. Messrs. Cooper have supplied these easels to members of the Royal Family. The floor is covered with a Moquette carpet in Louis Quinze style, with blue centre and cream border. Finally, the lighting of the room has been carried out with considerable thought and care, as, indeed, is the case with the other apartments we have described.

Comparisons are notoriously odious, but we are relieved of any necessity for making them by the fact that Messrs. Cooper had their exhibit complete in every detail on the opening day, and were alone in this respect. Therefore no comparison with other exhibits could be made, if we were inclined to institute one. Of this, however, we are assured—viz., that electrical engineers should be grateful to this enterprising firm for showing how beautifully the incandescent light is adapted to the lighting of rooms furnished and decorated with all the taste and skill which has been lavished on the suite we have described. We trust that Messrs. Cooper may reap the substantial reward they so well deserve.

One of the largest and most important exhibits in both Machinery Department and Main Transept is that of **Siemens Bros., Limited**, and it will, we think, be not only intensely interesting to electrical engineers, but also one in which public interest will be most largely kept up. This will accrue from the exhibition of the model electrically-lighted theatre, which was shown in Frankfort; the daily demonstration is to be given of telephonic curves and tones and an analysis of the interior working of the telephone; the manipulation of a 50,000-volt current, strong enough to pierce ebonite 17 mm. or glass ½in. thick, or give an arc of 12in. across water, or light 500 100-volt lamps in series; a new type of transformer in the form of a length of thick cable; an electric winch, electric passenger and dinner lift in working order, to say nothing of the ordinary sight of Siemens dynamos in working, motor-dynamos, electric tools, a new system of automatic block signalling for railways, automatic electric mine exploders, besides telegraph and cable instruments in profusion. It is perfectly evident all this cannot be described in one article. We must begin with a cursory review of the salient features in their order. In the first place—the dynamos. At the Machinery Hall we see one of the large Siemens continuous-current dynamos, designed for 120 volts and 1,600 amperes at 350 revolutions, the ordinary standard type of dynamo for central station work, as shown at the Naval Exhibition. Three of these were there used, and all of them have been since sold to the St. James's and Pall Mall Company. This dynamo is not shown running. Of the working plant, we see an H B Siemens bar armature dynamo, continuous current, for 120 volts and 450 amperes, at 420 revolutions, as used for shiplighting, driven by a Willans and Robinson closed type of engine, of 75 i.h.p. Another dynamo of the same type, working in parallel, giving 120 volts and 200 amperes, at slower speed, 320 revolutions. This is driven by an open-type Scott, Willans, and Robinson engine. A fourth dynamo is a Siemens alternator, not running, shown coupled direct to a Tangye engine, making a "ship set," as supplied to the P. and O. boats, giving 105 volts 200 amperes at 200 revolutions. A fifth dynamo is an alternator, which will be used for supplying current for the high-tension experiments; these are to be ready at the end of the month. The dynamo supplies 80 volts 500 amperes, driven at 420 revolutions by a Willans G G engine. The current will be transformed up first 80 to 2,500 volts by the new "cable" transformer, and then again by the large Siemens 50,000-volt transformer. This is the highest ever attempted by a dry transformer—*i.e.*, not immersed in oil—and is five times that of the Deptford transformers. It will give a spark of 2in. in dry air. The capacity of the transformer is two amperes and 50,000 volts, or 180 h.p. In one corner of the exhibit is an electric winch, which will lift five tons 90ft. a minute. The motor is so arranged that the load can be suddenly arrested without affecting the armature. The efficiency is 93 per cent. Specimens will be shown of electric drills intended for piercing the sides of ships, the frame of the drill holding on to the ship by its own magnetism. This will be shown in action, as also ventilators, brushes, and other electric tools. A passenger lift to carry 10 persons, made by Waygood, has been fitted with complete electric gear, and will be working, raising visitors to the gallery. A dinner-lift will be in operation close beside it. The transmission of power will be also shown by a motor-dynamo, or continuous-current transformer, 100 to 800 volts. This will supply current to the block system signals. These will be of great interest to railway engineers. They consist of cast-iron sleepers carrying the rail, containing contacts depressed by the weight of the engine; the engine thus automatically blocks its own line. Another application of the motor is that of an electric fire engine of 30 h.p., Messrs. Siemens's own design. It will throw water by electricity instead of steam, by being connected to the street electric mains through contacts fixed near the standpipe. The show in the Transept contains several arc lampposts, a tall lattice mast carrying six arcs for lighting large areas, and four posts for street lighting. Messrs. Siemens have also six large arc lamps outside the turnstiles. Two large showcases contain some magnificent specimens of their electric cables, concentric and single conductor. One of the latter contains 1,000 square millimetres. The "cable" transformer mentioned is a novel piece of electrical apparatus. It consists of a huge piece of cable about 5in. diameter and 10 yards long, like a great hosepipe. This is the transformer; it has a flexible iron core and two copper windings. The length regulates the voltage, and they can be cut off in lengths to requirements. The one shown is to transform 2,500 to 80 volts, and of great capacity—500 amperes. Smaller ones for house lighting could be inserted in the main or hung up in a cellar. The model theatre is arranged in the Pompeian Court. Here miniature stage effects will be shown—sunset, Alpine glow, moon effects, sunrise, lightning, and so forth—all electrically produced by incandescent lamps and electric motors, and controlled by one man at one switchboard, placed on full view in front of the stage. We have said enough to show the interesting nature of Messrs. Siemens's exhibits; further details must be left for future description.

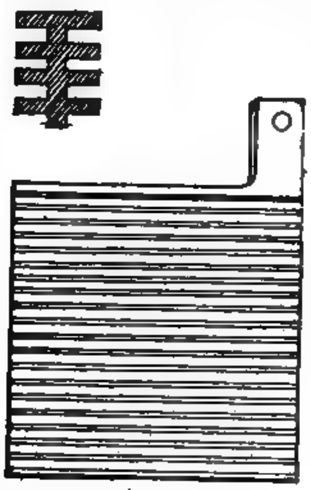
Conspicuous in the North Nave is the stand (No. 117) of **Messrs. Benham and Froud**, of the Chandos Metal Works, Chandos-street, Strand, W.C. Here are shown specimens of very high-class metal work in the shape of electric light fittings, both for public buildings and private houses. Among the examples exhibited are: A large nine-light brass electrolier, the arms of which are repetitions of brackets recently made for the ballroom, Government House, Rangoon; an electrolier, with corresponding wall lights, mirror bracket, etc., in finely-chased mercury-gilt work; an electrolier, silver-plated in the style of Henry IV. of France; a silver-plated bracket, a replica of those made for the Royal room, Lyric Theatre; two ceiling lights in copper and brass, representing (1) a bouquet of flowers, (2) a group of fan palms; a bracket as now in use on the stage at Terry's Theatre in "The Times"; a wall light of quaintly-embossed copper, in the form of an owl, the lamps being introduced within the repoussé work; a number of ceiling lights, electroliers, brackets, table pillars, girandoles, floor lamps in gilt, silver-plated, copper, brass, hammered iron, etc., the whole of which have been designed for, and manufactured at, the Chandos Metal Works. A model is shown of the ball and cross on St. Paul's Cathedral, made at these works, A.D. 1821, and adopted as the company's trade-mark. Above the stand are examples of weather vanes with lightning conductors attached.

In the Mediæval Court, Messrs. Benham and Froud have fitted up a representation of the east end of a very modern church, which is lighted electrically. We shall

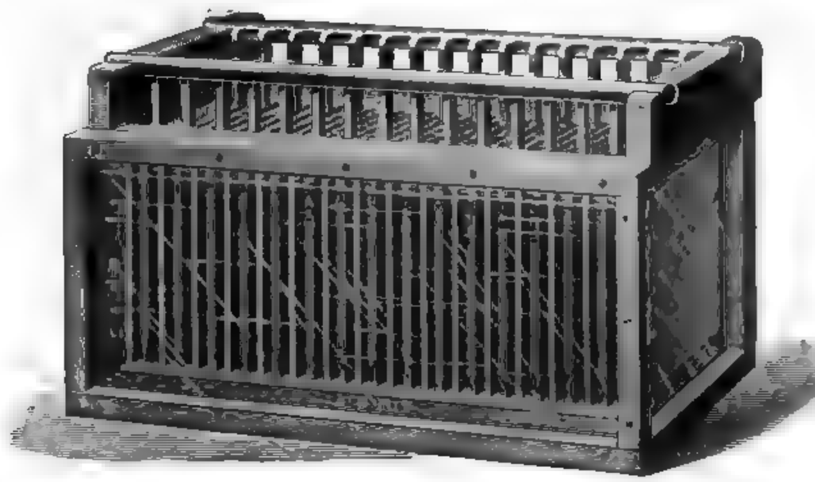
Specimens of Messrs. Benham and Froud's Electric Fittings.

describe this exhibit fully in another issue. Meanwhile, we give illustrations of some of the Chandos fittings.

The Epstein Accumulator Company, Stand 9, are exhibiting their make of secondary batteries. It may be remembered that this is a modified Planté battery; the formation of the plates is obtained by placing them in a 1 per cent. solution of nitric acid and water. We remember having tried this method of formation in 1882, but failed to obtain satisfactory results; hence credit is due to those who have overcome the difficulties which haunted the earlier experimenters. If we remember rightly, one insuperable difficulty to us was that using flat plates we got an excellent formation, but in a very short time the formed surface stripped from the unattacked lead backing. Mr. Epstein uses a slotted plate, and contends he obtains by his process a firmly adherent coating. His forming solution is heated till it boils, and the boiling continued till the plates present a dull grey appearance. After which they are dried in the air. Lead treated in this manner is made to serve for both positive and negative plates. In the process of forming positive electrodes, the former greyish-yellow colour changes into a deep dark brown, almost a bluish-black hue, and the process is completed as soon as the elements have attained that colour and an abundant development of oxygen has taken place. The oxygen of the peroxide of lead produced on the positive elements which are to be changed to negative is absorbed by the effect of the electric current, and the bodies are reduced on their surface to porous metallic lead. The process of forming negative elements is finished when the deep dark brown, or bluish-black colour of the positive element used for the purpose has changed into a bluish-grey hue. It is said that only a few hours are necessary to form a plate by this method.



Epstein's Element.



Epstein's Secondary Battery, R 31 Type.

In Epstein's form of electrode, which exposes a large surface, and which, when treated by his process, is said to quickly acquire a considerable electrical capacity, the increase in surface is obtained by deeply grooving both sides of the plate, as shown in elevation and section in our illustration. The soft active material, after being "formed" is said to key itself between the ledges, and it does not appear to fall off even if the battery is roughly used. From figures supplied by the manufacturers, Messrs. Woodhouse and Rawson, the following table has been compiled:

Mark and number of plates.	Weight of plates.	Approximate external dimensions of box.			Working rate.		Capacity, Amp.-hours.	Approximate weight of complete cell.
		Length inches.	Width inches.	Height inches.	Charge. Amp.	Discharge. Amp.		
R 3	52 lb.	15	3¼	17	1 to 30	1 to 30	120 to 150	81 lb.
„ 5	100 „	15	5¼	17	1 „ 60	1 „ 60	240 „ 300	155 „
„ 7	150 „	15	7½	17	1 „ 90	1 „ 90	360 „ 450	225 „
„ 9	200 „	15	9¼	17	1 „ 120	1 „ 120	480 „ 600	295 „
„ 11	250 „	15	11⅛	17	1 „ 130	1 „ 150	600 „ 750	368 „

The normal maximum rate of discharge is given as 30 amperes per positive plate, and for short periods this rate may safely be doubled. The capacity at the above rate of discharge is about 120 to 150 ampere-hours per positive plate; at half this rate the capacity is about 140 to 170 ampere-hours per positive plate. The liquid used is a 10 per cent. solution of sulphuric acid and water.

Our illustration shows one of the R 31 type, as shown at the Palace. Other lighter and cheaper cells are manufactured, as will be seen by an examination of the lists of the company.

Messrs. F. Wiggins and Sons, mica merchants, of 10, Tower-hill, and the Minories, E.C., have in the South Gallery one of, perhaps, the finest exhibits of mica that has ever been shown. It is evident that the firm have spared no pains in preparing and arranging their stand, and, to their credit, be it said, they were ready from the first. Here will be seen some magnificent mica slabs, both in size, colour, and geographical origin. They are from all quarters of the world—viz., Bengal, Madras, Ceylon, Brazil, North America, Canada, North Carolina, Labrador, Guatemala, etc. The colours of the slabs comprise what are technically known as ruby, pale green, amber, and black spotted, of which ruby is the most valuable. The firm also show mica worked up for different purposes, such as strips for dynamo armatures and commutators, a use for which it has been much employed of late; also turned washers, bushes, compass cards, lightning protector strips, and lamp chimneys. In a corner of the showcase a column of turned mica may be seen. Being composed of several different varieties, on looking through it the various colours are seen the reverse way of the layers, and very beautiful they look. This is a novel and interesting exhibit. We advise our readers not to leave the Palace without having a look at Messrs. Wiggins's stand in the South Gallery.

Messrs. Johnson and Phillips' exhibit will excite considerable attention. Conspicuous among the many conspicuous objects at this Exhibition are the buoys shown by this firm. It must, however, be with the less prominent objects that we commence our examination of this stand. One of the best known arc lamps of the day is that of Brockie-Pell, manufactured by this firm. Specimens of these lamps hang all round the stand, and externally have the appearance shown in the accompanying illustration. From the point of view of the purchaser, this lamp is recognised as burning steadily, and giving a minimum of trouble. One of the most recent departures of this firm is in the manufacture of secondary batteries, they being the manufacturers of the D.P. cells for Messrs. Drake and Gorham. These cells are illustrated herewith. The plates are formed on the Dujardin process, and are rendered active by a combined depositing and oxidising action performed by electrolysis in an alkaline bath of nitrates composed as follows: Ten kilogrammes of water, two kilgrammes of sulphuric acid, one kilogramme of alkaline nitrate (of soda, ammonia, potash, or other suitable alkali).

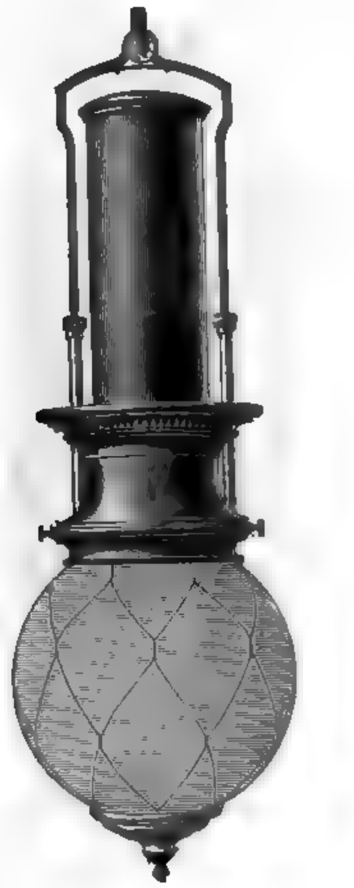
By the passage of an electric current nitrate of lead is formed, and by the acid of the bath this is converted in a continuous manner into sulphate of lead and afterwards into peroxide of lead. In some hours, without discharging or reversing the current, the positive plates become covered with an adherent layer of crystalline peroxide of lead, which may be over a millimetre thick, and of great electrical capacity. In order to increase and regulate the formation of the salts of lead, it has been found that it is useful to introduce large volumes of air into the liquid. This may be effected either by forcing the air into the bath, by raising and lowering the plates, or by other convenient means; the reaction being thereby doubled whatever may be the composition of the bath. In order to facilitate the adhesion of the peroxide upon the plates, the latter are constructed of laminated lead. In a few hours the peroxide, which is formed at the expense of the lead, fills the interstices in the laminated plate. A systematic description of the exhibits will naturally group around three heads—cable apparatus, which includes buoys, grapnels, hauling gear, etc.; electric light generating apparatus, into which come prominently the various Kapp dynamos; and electric light apparatus generally, including storage batteries, transformers, mains, switches, etc. Of all these more anon.

At Stand No. 2 we find the exhibits of **Messrs. Swinburne and Co.** The name of Mr. Swinburne is well known to all electrical engineers, and his all-round experience is pretty extensive. Cradled in the works of Mr. Swan, at Newcastle, his knowledge of all that concerns lamps was obtained at first hand. Afterwards, in this field, he attempted to walk alone, but found it better to associate himself with the firm of Crompton and Co., where he necessarily gained large experience in dynamo work. Mr. Swinburne paid special attention to transformers and measuring instruments. Commencing business himself, he made a speciality of the form of transformer which has been named the "Hedgehog," because of the loose wires at the ends, which remind one of the bristles upon the back of one of the innocent denizens of our hedgerows.

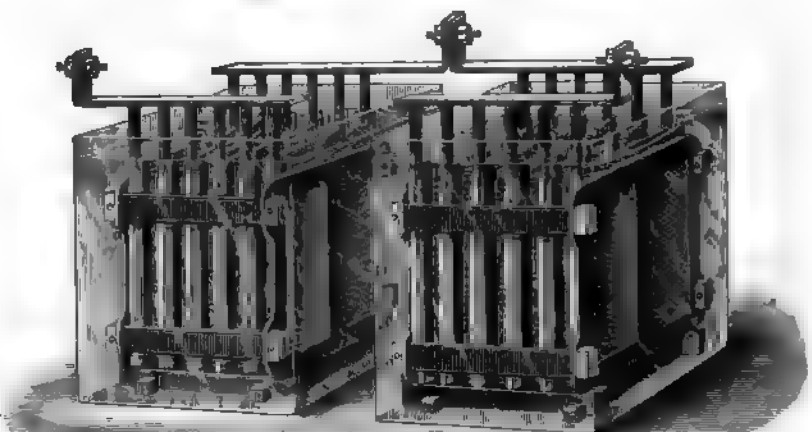
As might be expected, then, this firm exhibits a number of Hedgehog transformers. These transformers have been the subject of so much discussion that little need now be said about them. The makers claim that in designing closed-circuit transformers engineers have neglected the loss of power in the iron, and that as the loss in the iron goes on all day and all night it is really very serious. They, therefore, make a transformer which has very little iron, for which they claim a much higher all-day efficiency. This advantage cannot be obtained without some drawback. The drawback generally urged in this case is the idle current taken on open circuit. This does not represent power, but it may be in some other respect troublesome. Though the makers have never found this idle current give any trouble in central stations, they have foreseen that there may some day be difficulties, and have therefore set to work to bring out commercial alternate-current condensers, which will be described separately. The ordinary transformer, with its case, is illustrated herewith. In addition to the ordinary transformer for housework, special designs for other purposes are shown. Two forms of street lighters are exhibited. One is the ordinary form with the stoneware case replaced by a light cover made of roofing material. This is arranged to fix on posts for town lighting, as at Chelmsford, or to attach to walls as is usual in America. Each transformer feeds into a low-pressure circuit which supplies a number of lamps. This form is also used for arc lighting. In this case constant-current transformers are used. These take 2,000 or 100 volts on the primary, and give 10 amperes on the secondary. The trouble and expense of secondary leads is entirely done away with. It is needless to say that an arc lamp will always burn more steadily with a constant current than under constant pressure, and this condition is much more easily obtained with alternate than direct currents. In direct-current work it is usual to run special arc circuits, or else to couple arc lamps in pairs in series with resistance. In alternating-current systems, one high-pressure parallel circuit can supply everything.

For incandescent street lighting, Messrs. Swinburne and Co. exhibit a fitting which consists of a small transformer with case, shade, and lampholder complete. This takes 2,000 or 1,000 volts, and has a 50-volt 32-c.p. lamp. The object of this arrangement is to admit of street lighting with incandescent lamps without special secondary leads. In fact, it is very much as if Messrs. Swinburne and Co. had brought out incandescent lamps for 1,000 or 2,000 volts.

Swinburne and Co.'s Transformer.



Brockie-Pell Arc Lamp.



D. P. Storage Cells.

THE

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CONTENTS.

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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1892.

We had intended to conclude the review of the past year with our last issue, but space was required for more pressing matter, hence one or two questions upon which it is desired to comment remain till now. A sane man reading the ephemeral literature of the day, as represented by the great London dailies and the metropolitan and provincial weeklies, can hardly realise that this is a time forming part of a civilised era. At a moderate computation, one-half the papers are dependent for existence upon quack advertisements, plus those emanating from swindling company promoters. Of the latter we have often spoken, of the former we have still to speak. There is a tale told of two men walking down a street, one a qualified medical practitioner, the other a quack doctor. The former asked the latter why the public deserted him with all his learning and experience to patronise the disciple of nostrums. Said the latter: "Your question may be best answered through another, How many men possessing a fair share of common sense should you imagine to exist? Say per cent?" "About 5 per cent.," replied the qualified practitioner. "Well, those five are your patrons, the rest mine," said the quack; and this, no doubt, is pretty near the truth of the case. The nostrums advertised find purchasers—yea, and purchasers in large numbers, otherwise the quantity of advertising would be lessened. For many years quacks have sought to qualify their productions by the adjective "electrical." Every ailment under the sun is, according to them, to be cured by something "electrical," or something "magnetic," which terms for the nonce may be taken as identical. Those who possess a rudimentary knowledge of electrical science know that nine-tenths of the statements made by these advertisers are altogether inaccurate. For the moment let us refer to another subject which runs on parallel lines to the above. The editors and the news purveyors to the papers are supposed to be men of light and learning, to be men who desire to leave the world in a better and a happier state than they found it. Of course we assume that the first object is to make their pile. Well, what is the position of these learned purveyors of mental pabulum? Just this—that the most atrocious statements are propagated with regard to matters electrical, that a lie about such matters is more likely to be believed than the truth. Men are led to expect what they ought never to have been led to expect, making it necessary in the interests of progress to first eradicate the false before a lodgment can be given to the true. The most mendacious statements come over here, for example, ticketed with the labels of news agencies, from America. The senders of the telegrams ought to be electrocuted; in fact, that punishment is too good for them—it would require a Dante to suggest a suitable one. Talk about a lying spirit being abroad; that is but a mild expression. Here is a sample of the latest. Edison—and, mind you, these purveyors always imagine their "copy" must be taken if they can bring in the name "Edison"—is said to have discovered a way by means of which a "score or so of men" can defend a fortress against an

army by using a jet of water. That statement has been read by tens—even by hundreds—of thousands of scientifically ignorant readers, and, like all nostrums, eagerly swallowed. One would think it was a difficult task to ordinarily fill a newspaper with reading matter, instead of the difficulty being how to deal with too much matter. Every electrical engineer knows what peculiar pranks young electricians have played, and how men have danced and ejaculated with amusing verbosity when undergoing these practical jokes, but there is not one man amongst them but knows the absurdity of such a statement as the above. We wonder at the dissemination of such silly tales from a politician's point of view. If defensive works are necessary, say those who read these items, why not employ the cheap and efficient method "we are told a celebrated electrician has discovered"? Why spend money upon huge works, upon guns, and upon a standing army? By the bye, reader, did you ever try to disabuse anyone's mind of the untruthfulness of such statements? If not, pray try it.

Here, then, are two directions in which the efforts of the technical press are neutralised by the crass stupidity of those who arrogate to themselves the sole right of belonging to the "journalistic profession." They permit quacks to entice the public to buy and use nostrums, and they carelessly or wilfully permit their columns to be the vehicles for the propagation of the most astounding electrical paragraphs that the mind of man can invent. One of our contemporaries in England has made, and often repeated, attacks against electrical quackery, but its efforts must fail, because its readers are not those to be easily caught, and those easily caught are not among its readers. What is the use of a parson declaiming to those present forming his congregation about non-attendance? It is the editors of the dailies and weeklies who hold in their hands the power to suppress quackery, but they won't use it because the quacks advertise more than all other people combined. *Hinc illæ lacrimæ.*

Having said this much, we will add to the list of firms noticed that of—

J. D. F. ANDREWS AND CO., which, during the past year, had made rapid progress with the system of concentric wiring, and has carried out many important installations on this system in London and the country, the most important of which are the Waterloo grain warehouses, with 200 50-c.p. lamps, and the Park-hill petroleum stores, with about 100 16-c.p. lamps, and three of 300 c.p., the dynamo being about one-third of a mile distant. Another important installation is that of the Tyne Theatre, Newcastle-on-Tyne, where there are 200 16-c.p. lamps, and six of 200 c.p. As a proof of the great success of this system, Messrs. Andrews and Co. have already concluded three contracts for the Mersey Dock Board, Liverpool. The system may be examined at the firm's offices at 41, Parliament-street, where they have an installation of 100 lights connected to the mains of the London Electric Supply Corporation. The majority of the insurance companies have had the system under their consideration, and have drawn up a set of rules which give latitude for its introduction.

BLAKEY, EMMOTT, AND CO. state that it is not generally known that during the last twelve months the electric light has been installed in many of the public buildings, shops, and residences in Preston. A temporary generating station was fixed twelve months ago for the purpose of ascertaining what inclination the people of Preston had for the electric light. The National Electric Supply Company, Limited, which company obtained a provisional order for lighting the town for a term of forty-two years, intended that the maximum output for this station was to be only 1,000 8-c.p. lamps, but long before the plant was working the amount of lamps was greedily taken up on a basis of 12s. per lamp per annum. The company, to meet additional orders, were compelled to fix another machine, bringing the capacity up to considerably over 2,000 lights, which are now actually working, and orders for more daily coming in; but with the before-mentioned plant it is impossible to execute the further orders. They are, therefore, being filed for future connection from the central generating station which the company have now commenced to erect. The outside wiring has been overhead, there being four circuits from the central station in Corporation-street, two along pole routes through the most important thoroughfares in the town, and two over house tops, telephone fashion. The whole of the wires and cables for this undertaking have been manufactured by the Northern Electric Wire and Cable Manufacturing Company, Limited, Halifax. The present plant supplied by Messrs. Blakey, Emmott, and Co., Limited, of Halifax, consists of three dynamo machines of 18,000 watts; and a dynamo of 30 kilowatts has been specially designed for this station. It gives an output of 140 volts and 430 amperes, at 350 revolutions per minute. The magnetic system is octagonal in shape, with four internally-pointing poles. The yoke is of the best cast iron, and the magnet bars of wrought iron. The four magnet coils are wound upon four metal formers with brass cheeks, and can be readily removed or put in place. The armature is the cylinder type, and is built up of thin charcoal iron washers, carefully insulated from each other and mounted on a gunmetal spider. The diameter of the armature core is 21in. It is insulated with mica before being wound. The windings are laid on Gramme fashion, and consist of 200 turns of copper tape in 100 sections of two turns each. Nine driving horns of stiff vulcanised fibre are provided, which run the whole length of the armature. The windings are securely held in place by bindings of phosphor bronze wire. The commutator is made up of hard-drawn copper bars insulated with mica, and is carried upon the shaft by means of brass rings and fibre insulation. The armature connections are soldered to spokes projecting from the commutator segments. These spokes are afterwards covered by a disc of thin fibre, which not only prevents dust from lodging, but also promotes a strong draught through the armature from the pulley end and expels it at the commutator. Four sets of three brushes each are used, mounted on an adjustable rocking frame. The brushes are connected by four separate connections to the terminal-boards. The brushes are of gauze. The shaft is of Bessemer steel, and runs in long bearings of gunmetal. Sight-feed lubricators and oil-draining arrangements are provided. The magnet yokes divide in a horizontal line, and by raising the top half of the magnets the armature can be examined in place. This dynamo runs entirely without sparking or overheating, and notwithstanding the magnets are only shunt-wound, the lead given to the brushes has only to be altered a few degrees for any output from no load to full load.

The machine is the usual 90-kilowatt, or 3,000 lamps of 8 c.p., run at its ordinary speed of 500 revolutions, at which output it has an electrical efficiency of 97 per cent., and a commercial efficiency of over 93 per cent. For this output the armature is drum-wound with special end connections. The National Electric Supply Company, Limited, now propose to put down a plant on the low-tension system similar to that now working so successfully in the St. James's district in London, which Messrs. Latimer Clarke, Muirhead, and Co. have pioneered. The first portion of the town to be served from this station will be the compulsory area with the adjoining streets, in which it is sanguinely anticipated that a demand for at least 20,000 8-c.p. lamps will be made. Distributing-boxes will be laid in such positions as to ensure an even potential over the mains. A large number of meters have been successfully introduced, and it is the intention of the company to continue the supply. The amount charged to consumers is 8d. per Board of Trade unit, with a discount of 15 per cent. if paid within twenty-one days. The firm find by experience that this compares very favourably indeed with the cost of Preston gas, which, by the bye, is 2s. 9d. net, and of very bad quality. Preston, with its numerous mills, is favourably placed for a successful adoption of the electric light, and the way in which the present engineer and manager, Mr. F. F. Bennett, has worked up the present installation augurs well for the future. The Halifax Mutual Electric Light and Power Company, Limited, are continuing to do good work in the way of public lighting in the town of Halifax. It is nearly two years since this company was formed by taking over the central station then being worked by Messrs. Blakey, Emmott, and Co., Limited, and also that of an opposition company, which has since ceased to exist. The wires, by permission of the Halifax Corporation, are all overhead, and the company is supplying current for about sixty arc lights of ten amperes, and 1,000 incandescent lights of 8 c.p. Two systems of charging are adopted in the town—viz., one at the rate of 12s. per 8-c.p. lamp per annum, and £12 per ten-ampere lamp per annum, and at 8d. per Board of Trade unit. The furthest point served from the central station is about 1,700 yards. The low-tension system is adopted throughout. It has been found during the past two months that the company could not keep pace with the large demand for current at their present premises, therefore negotiations have been entered into with the Halifax Corporation for leasing from them a convenient site, and very shortly it is hoped that the company will have a capacity of at least 20,000 8-c.p. lamps. Two systems of engines are used for driving—viz., Armington-Sims's high-speed, and Tangye's. The dynamos and all other electrical fittings in connection with the installation are of the well-known Blakey-Emmott type, and Mr. Walter Emmott, of Blakey, Emmott, and Co., Limited, Halifax, is the managing director. The meters adopted up to the present have been the Aron, which appear to be giving general satisfaction, both to the Emmott Company and to the consumers. The price per 1,000 cubic feet of gas in Halifax is 2s. net, and judging from the weekly reports of the expert who tests the illuminating power on behalf of the ratepayers the average illuminating power is about seventeen candles. Taking into account this very low figure with high efficiency of gas, it speaks very well for the prospects of the electric light for the future when the present output and very large demand for current is considered. The whole of the wires and cables for this *installation* have been manufactured by the Northern Electric Wire and Cable Manufacturing Company, Limited, Halifax.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

STEAM ENGINE ECONOMY.

SIR,—We were interested in Prof. Ewing's report on the above. Some years ago we put up a large resistance (40 ohms) of very open iron wire spirals, for the purpose of testing alternating-current dynamos. From careful experiments we found that the current passing, as measured by a Siemen's electro-dynamometer, multiplied by the E.M.F., measured by a Cardew voltmeter, did not represent the electrical horse-power being given out. Indicator diagrams taken from engine showed that less horse-power was indicated in the cylinders than that in the external circuit, calculated as above.—Yours, etc.,

THE ELECTRIC CONSTRUCTION CORPORATION, LIMITED.
(T. Parker, Chief Engineer and Head Manager.)
January 19, 1892.

SIR,—In reference to the letter of Messrs. Willans and Robinson in your columns of last week, we would wish to state that it was not our intention to challenge record runs, and therefore in the tests made by Prof. Ewing no arrangements were made conducive to exceptionally high economies. These are the use of very high boiler pressure, and a separator or other means for obtaining very dry steam.

In the present tests the pressure at the engine never exceeded 75lb., and the steam was not dried.

It would be interesting to know with what steam pressure and engine Mr. Willans obtained the results stated by him at the meeting of the Institute of Civil Engineers last spring, for we are unable to find any mention of these two important factors in the *Proceedings* of the Institute.—Yours, etc., C. A. PARSONS AND CO.

Heaton Works, Newcastle-on-Tyne.

THE LATE ALEXANDER WATT.

We regret to have to record the death, on the 15th January, of Mr. Alexander Watt. The late Mr. Watt was the third son of Mr. Charles Watt, and was born in 1823. He was educated at Camden Town with a view to entering the medical profession, but in 1839 took up definitely the study of electro-metallurgy and electro-chemistry. From that time to the date of his death Mr. Watt was an indefatigable worker and writer. His books have been widely read, and his contributions on electro-metallurgic and electro-chemical subjects to the technical papers have been very numerous. His latest contribution, on the "Electrolysis of Gold Salts," was in course of publication in our columns. The late Mr. Watt cannot be said to have ranked as a pure scientist; indeed, the purely scientific was a phase of work which he scouted. His aim was always to get at something which could be put at once to a practical use, and for which he could obtain a practical recognition. A mere investigation with no practical end in view was to him a sheer waste of time and energy, hence his books and papers rather appeal to the working than to a highly-trained scientific circle. In all his work he was extremely cautious and painstaking, nor should one trait in his character be left unrecognised—his great and intense desire to see justice done to the labours of his brother.

Telegraph to China.—The *Times* correspondent in Burmah announces that the telegraph line is now almost completed between Bhamo and Nampoung Creek. The wires will then extend to within less than 100 miles of the terminus of the Chinese telegraph line in Momein. The Chinese authorities will be asked to continue their line and connect it with ours. An alternative telegraph line between England and China would be thus established.

THE DETERMINATION OF THE EFFICIENCY OF DYNAMOS.

BY GISBERT KAPP.

The power given out by a continuous-current dynamo, in the shape of current and pressure, can be measured with a very fair degree of accuracy. The ordinary commercial ampere and voltmeters now obtainable from good makers may be relied on to be accurate within a few per cent., and in some cases within a fraction of 1 per cent. In any case there is no difficulty in recalibrating the instruments sufficiently accurately to make sure that the error shall not exceed ½ per cent., so that the maximum possible error in computing the power need not exceed 1 per cent., and the probable error will be ½ per cent. Within these limits, then, we are able to tell what the output of any given machine is, and if we could determine with equal certainty the power mechanically supplied to the machine, the determination of the efficiency—that is, the ratio of electrical power given out to mechanical power supplied—could be made with a high degree of accuracy. But, unfortunately, the determination of power mechanically is not an easy matter, and is especially difficult when the power must not be absorbed by, but must be transmitted through the measuring instrument. Hence electrical engineers have very early in the development of their industry begun to cast about for some method whereby the efficiency of dynamos might be determined without making a mechanical measurement of power at all.

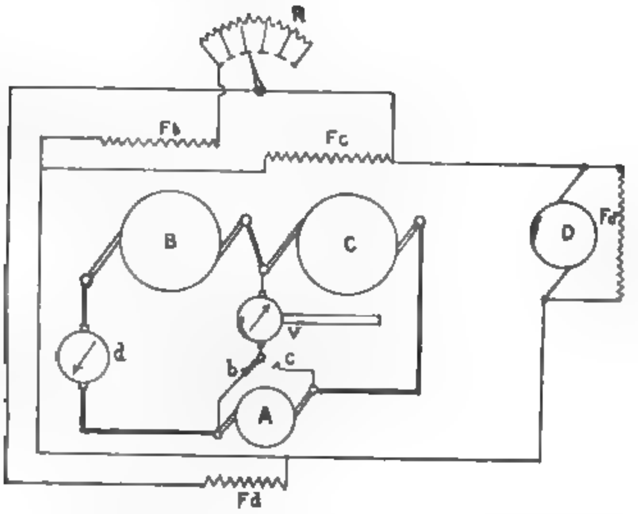


FIG. 1.

Probably the first to devise such a method was Major Cardew some six years ago, and his method was prescribed for dynamos supplied under his specifications to the War Office. To make an efficiency test three machines were required, preferably differing in output by the amount of power lost in each. The largest machine was arranged to supply current to the medium-sized machine, and that again was arranged to supply mechanical power by belting or direct coupling to the smallest machine. In order to work each machine at normal load their sizes must obviously differ. Thus, if A, B, and C be the three machines, and if B is rated as a 50-kilowatt dynamo, then it will work as a motor fully loaded if 50 kilowatts is supplied to it electrically. Its mechanical output, or the power it supplies to C, must be less than 50 kilowatts, because some power is lost in the machine itself. Say the net power available in the spindle of B is 42 kilowatts. We supply, then, 42 kilowatts to the spindle of C, and obtain from it again less power electrically, say 35 kilowatts. The machines will, therefore, be all working under full normal load if they are designed for an output of 50, 42 and 35 kilowatts respectively. Should B and C happen to be machines of equal size the test can still be applied, only B will be slightly overloaded and C will be slightly underloaded. This does not materially influence the accuracy of the test, since the efficiency of a machine is nearly constant for loads anywhere near the normal. The power supplied to A need not be measured; all we measure is the electrical power supplied to B and the electrical power obtained from C. The ratio between the two is the combined efficiency of B and C, and the square root of this ratio is the efficiency of each machine taken singly.

Another method for testing efficiency was devised some years ago by Dr. Hopkinson and shown to several engineers at the works of Messrs. Mather and Platt, Manchester. The improvement consisted in supplying not the whole of the power required by B (as in Cardew's test), but only the power lost in B and C, the current given by C being used to work B as a motor. In Hopkinson's method the two machines are mechanically connected, preferably by joining their spindles by a coupling. Over this coupling is placed a pulley, which takes the belt through which the waste power is supplied. In the arrangement adopted at Manchester the driving belt was passed through a Hefener von Alteneck transmission dynamometer, by which the power required to keep the whole system going was measured mechanically. The accuracy of this method is certainly greater than that of the direct method, where the whole of the power is measured mechanically, because an error in the reading of the dynamometer only affects the determination of the waste power, but some slight error may still occur. Say, for instance, that the efficiency of the two machines combined is 80 per cent. Then 20 per cent. of the power of one machine has to be supplied by the belt, and must be measured on the dynamometer. An error of

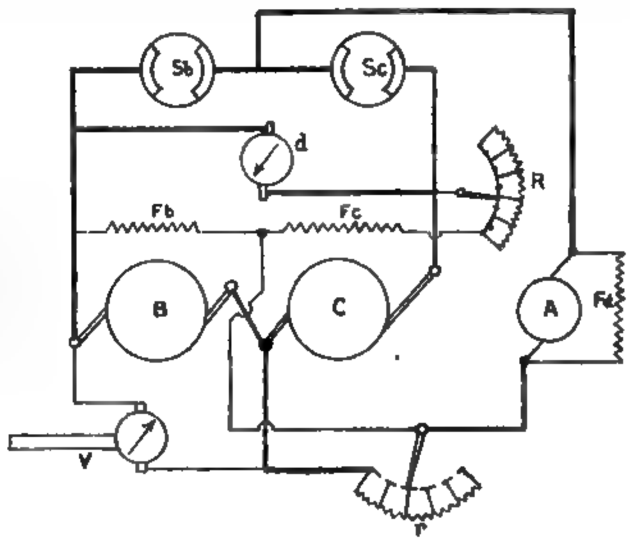


FIG. 2.

10 per cent. in this kind of power measurement may easily occur, and in this case the power supplied would be estimated at either 18 or 22 per cent., accordingly as the error is positive or negative, causing an error of about 1 per cent. in the final result. Apart from the inconvenience of having to rig up a dynamometer, there is the further objection that we must make the test by means of two totally different sets of measuring instruments which are not directly comparable with each other, and that it is therefore not possible to compensate the errors in the calibration of one set of instruments by those in the other set.

In this respect Cardew's test has an advantage. Not only do we use the same kind of instruments when testing the power supplied and the power obtained, but we can by a suitable arrangement of switches use absolutely the same instruments for both circuits, and then any calibration errors in one set of readings can be partially or wholly compensated by the errors in the other set of readings.

The objection to Cardew's method is that it requires the use of an engine and dynamo more powerful than any of the machines to be tested, and such plant is not always at hand or easily procurable. It is, however, possible to so alter the original arrangement that a comparatively small engine and dynamo will suffice for the testing of large dynamos. Using again the notation previously employed, if, instead of feeding glow lamps or resistance coils from the machine, C,

we let its current pass through B, and thus help working it as motor, then the machine, A, need only supply the difference between the power absorbed by B, and that delivered by C. We have, in fact, the electrical analogue to Hopkinson's mechanical method; and just as in this method a small belt suffices to keep a couple of big machines in motion at full load, so will here a small dynamo, A, suffice to keep a couple of large machines, B and C, working at full load. It is obvious that the connections between the three machines may be arranged in one of two ways. We may either put all the machines in series, in which case A must be a machine of low voltage and large current—*i.e.*, the same current as that for which the two big machines, B and C, are built; or we can place the three machines into parallel connections, in which case the small machine, A, must be of the same voltage as the two large machines, but need only give a small current. Theoretically, either method is equally good, but, as will be shown later on, there are some practical reasons which generally make in favour of the second or parallel arrangement of machines. Before entering upon a detailed explanation of either method it will be useful to anticipate and answer a question which naturally presents itself in connection with this subject. The question is the following: Why should we go to the trouble of running three machines if we want to know only the efficiency of one; and would it not be equally good to determine the efficiency of this one machine by running it idle as a motor and measuring the power required to drive itself? This would, in fact, correspond to the usual practice with steam engines of taking so-called "light running" or "friction" diagrams. The indicated power required by the engine to drive itself is thus determined, and the brake power may be computed in a rough and ready way by subtracting from the full indicated power that which was indicated when running light. The ratio of brake horse-power to indicated horse-power is then the efficiency of the engine. Why should we not do something similar with dynamos? Say we have a machine designed to give an output of 100 kilowatts. Leaving aside for a moment the power required for field excitations, which can be easily measured when the machine is in regular work, we wish to determine the efficiency of the armature as an implement for converting mechanical into electrical power. We run the machine light as a motor, and adjust the field strength so as to get the normal speed. The power required to drive the armature can now be exactly computed from the readings of an ampere-meter and a voltmeter. Say we find eight kilowatts is required. Following the analogue of the steam engine, we would conclude that, apart from the loss through armature resistance, $100 + 8 = 108$ kilowatts must be mechanically supplied to the shaft of this machine if 100 kilowatts are to be taken off at the brushes. If we further find that the field requires three kilowatts for excitation, and that two kilowatts are lost in armature resistance (both of which losses can be accurately measured), we would compute the total efficiency of this machine at $100/(108+3+2) = 88\frac{1}{2}$ per cent.

Whether this computation is correct or not depends entirely on the question whether we are justified in assuming that the waste of power (other than that caused by armature resistance) is the same at all loads; in other words, whether our eight kilowatts required for light running means a constant addition for any load. Theory and experiment both show that this is not so, but that the power lost increases with the load. The reasons for this increase are not far to seek. Consider what are the causes of this loss. Firstly, we have mechanical friction and air resistance; secondly, magnetic friction, or hysteresis; and, thirdly, eddy currents. The air resistance is unimportant and does not depend on the load; the mechanical friction, although it may be expected to increase with the load, is in itself so small that even if it were to increase by 20 or 30 per cent. at full load it would not materially affect the efficiency. As regards hysteresis the case is different. Generally speaking, the loss of power caused by it is of importance, and it is conceivable that this loss may increase with the load, not only by reason of an increase in the strength of the field, but also owing to distortion of the field. Both of these causes affect also the eddy currents, so that we may certainly expect the loss caused by them to increase with the load. Eddy currents occur in the core and in the armature bars only when the intensity of the field changes—that is, under or near the edges of the pole-pieces. When the machine is running light the strength of the field at the leaving edge of the pole-piece is practically the same as that at the entering edge, and, in fact, the same over the whole extent of polar surface, but when a considerable current flows through the armature bars the field becomes distorted by cross-induction. It becomes weakened at the entering edge and strengthened at the leaving edge, so that every bar whilst travelling from one edge to the other is passing through a gradually increasing field. In addition to the eddy currents produced at entry and exit only, as is the case when the machine is working light, there are now also eddy currents produced at the intermediate points. The eddy currents at the entering edge have decreased because there the field has been weakened, but those at the leaving edge have increased because there the field has been strengthened; and since the loss of power through eddy currents may be roughly said to be proportional to the square of the field strength, the gain in one place will not suffice to make up for the increased loss in the other, so that, on the whole, we may expect to find the loss by eddy currents increase with the cross-induction—that is, with the load on the machine. What has here been explained applies equally to drum and cylinder armatures, but in the latter there is another source of loss, absent from the former—namely, the influence of the internal winding. The current passing throug the internal wires of a Gramme armature produces a field the lines of which are more or less parallel to the diameter of commutation. This field is stationary in space, and its lines are therefore continuously being cut by the spindle, hub, arms, and other metal parts within the armature core. The larger the current passing through the armature, the stronger is this field, and the stronger are the eddy currents produced in these metal parts. The power thus wasted must therefore increase with the load. These theoretical considerations are completely verified by experiment, but to make such experiments it is, of course, necessary to determine the losses through eddy currents and mechanical and magnetic friction separately. Various methods exist for making this determination. According to one of them the field of the machine is separately excited, and the armature is supplied with current at various E.M.F.'s. It will therefore run at various speeds. If we plot speeds on the horizontal and currents on the vertical, we find that all the points lie on a straight line, and prolonging this line backwards we obtain by its intersections with the axis of ordinates that current which will just suffice to keep the armature moving imperceptibly. Call this C_o, the current corresponding to speed, *o*. Let C and E be current and E.M.F. at the normal speed, *n*, then the total power wasted in running the armature light is $W = C\,E$, and this consists of two parts—namely, the power wasted in friction and hysteresis, which

is $W_h = W \dfrac{C_o}{C}$,

and that wasted in eddy currents,

$$\text{which is } W_f = W \frac{C - C_o}{C}.$$

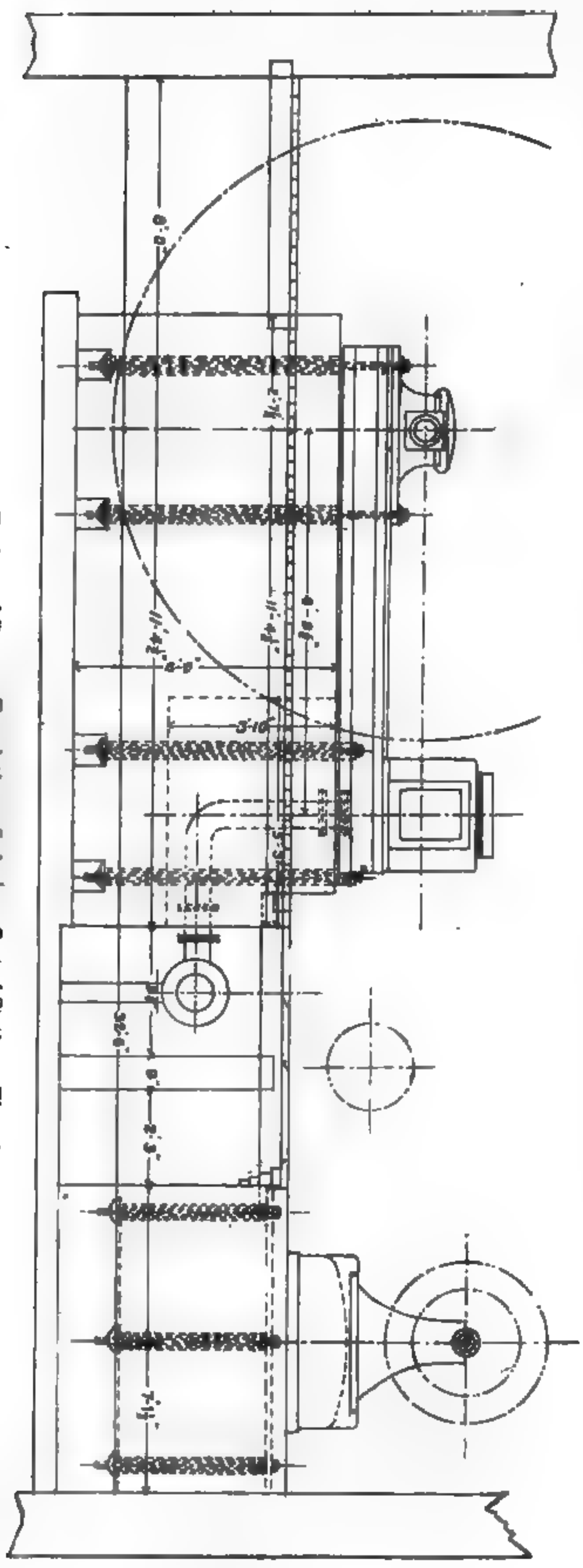
We neglect, of course, the power lost in armature resistance, which, with a machine running light, is insignificant.

Now, imagine two machines of the same type mechanically coupled and electrically so connected that one acts as motor and the other as generator. We supply current to keep the system in motion, and adjust the E.M.F. so as to get different speeds. By making the proper allowance for armature resistance, we can, from the observed values of speed, armature current, supply current, and E.M.F., separately calculate the power lost in eddy currents and hysteresis. It is not necessary to enter into the theory of such tests here; suffice it to say that the value for W_f thus found is always greater than the W_f determined when running light, and that with W_h this is generally also the case.

(To be continued.)

SYDENHAM ELECTRIC LIGHT STATION.

Continuing the account of this installation, designed and constructed for the Installation Company by Messrs. J. E. H. Gordon and Co., we give on this and two following pages illustrations of the details of the engine and dynamo



Engine and Dynamo Foundations—Sydenham Central Station. Elevation.

foundations, which sufficiently explain themselves without description on our part.

ELECTRIC LIGHT SUPPLY.

At the third ordinary meeting of the Dundee Institute of Architecture, Science, and Art, on 14th inst., Mr. C. Ritchie, of the Electric Construction Corporation, delivered a lecture on "Electric Light Supply." Mr. William Mackison, C.E., presided.

Mr. Ritchie began by remarking that but a comparatively few number of persons knew anything about the practical questions of generating electric current on a commercial scale until about 15 years ago, and stating that gas companies had been spurred on to provide better light since becoming aware of the advantages of electricity. Mr. Ritchie afterwards said that the question of the distribution of electric energy had always been a difficult one, but the alternating-current system had survived to the present day. The systems employed for the distribution of electric current over large areas might be divided into two classes—low-tension and high-tension. The low-tension systems of distribution were in practice always applied by continuous current. The simplest form was that wherein two copper conductors were carried through the streets of the area of supply, one being the lead, or positive, and the other the return, or negative. The advantages of this system were its simplicity and the adaptability of the current to the use of motors and accumulators, but its great disadvantage was the enormous cost of the copper required to cover any ordinary area of public supply. To overcome this objection there was in use the three-wire system, the third wire being for the purpose of balancing. While a great saving was effected under this system, it was not sufficient to meet the necessities of an area of supply when the lamps were widely distributed. The high-tension system might be either alternating or continuous, but as the pressure in the houses could not practically be more than 100 volts on account of the lamps, a transformer of some sort must intervene between the high pressure of the generating station and the low pressure of the houses. The most generally adopted system for the utilisation of high pressure was by means of alternating current, the pressure of the generating station being limited by the consideration of the insulation of the wires of the machines and transformers and of the conductors. This system was very simple in its elements, but it had several serious disadvantages, and there were heavy losses under it. Two methods of utilising the high pressure at the generating station were in use, the one by the employment of accumulators, and the other of motor-generators either alone or with accumulators. The advantages obtained from the accumulators were that the generating station need only be running for a comparatively short time each day, and might be shut down for lengthy periods during the summer months, when little current was being consumed. In order, however, to meet with the difficulty of the large expenditure necessary for the accumulators, the motor-generator system had been developed. Mr. Ritchie afterwards explained the working of this system in detail, remarking that as the demand increased the transformers in the sub-stations were put on the one after the other, and as the demand decreased an inverse operation was required to put the transformers out of circuit. By a comparatively small outlay it was a simple matter to adapt this system to any existing low-tension circuit or network of mains without dispensing with the present machinery and mains. It was necessary, he proceeded, to treat high-pressure mains in a different manner from low-pressure mains, just in the same way as with meter pipes. The lecturer afterwards explained the Callender-Webber system of bitumen, remarking that it consisted of a number of conduits formed by bituminous concrete, which were usually about 6ft. long, and said that in this system, as in the preceding, service-boxes were put in at certain intervals for drawing in the necessary cables. Another distinct system of high-tension mains was that in which the lead and return were concentric one with the other, two special forms of these being the Ferranti and the Siemens, under which a special form of service-box was used for joining up. The lecturer concluded by referring to the sites for installations, and to the designing and building of machinery.

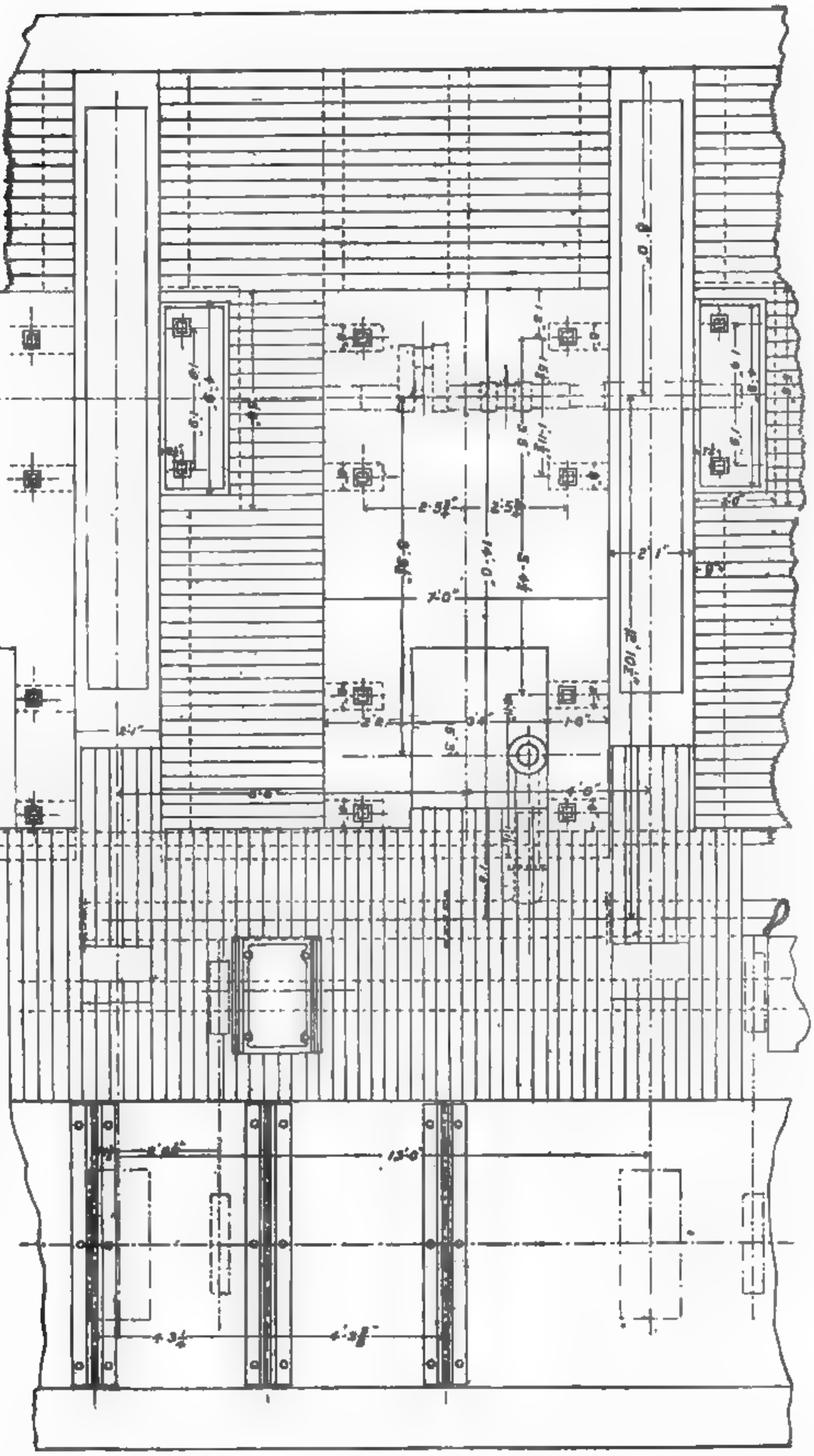
LONDON CHAMBER OF COMMERCE.

OVERHEAD WIRES—FRENCH CUSTOMS TARIFF—PALACE EXHIBITION.

The following communications emanating from the London Chamber of Commerce are interesting to electrical engineers.

"County Council By-laws on Overhead Wires.

"Dear Sir,—I beg to send you herewith copy of a letter which was recently sent to the County Council by this Chamber on the subject of the by-laws issued by that body in regard to overhead wires and also a copy of the reply. This letter was written on the representations of one or two of the members of the section that it was impossible to carry on their business if the regulations in question were strictly enforced. I would therefore be glad if you



Engine and Dynamo Foundations—Sydenham Central Station.

SCALE ¼ INCH TO ONE FOOT

would carefully peruse the correspondence and forward me any representations you may have to make on the subject, and especially as to whether you consider it necessary to hold a meeting to consider the matter.—Yours faithfully,

"KENRIC B. MURRAY, Secretary.

"January 15th, 1892."

[COPY.]

"London Chamber of Commerce, January 7th, 1892.

"H. de la Hooke, Esq., clerk to the London County Council, "Spring-gardens, S.W.

"BY-LAWS—OVERHEAD WIRES.

"Sir,—The attention of this Chamber has been recently directed by several of its members to certain by-laws made by the London County Council in pursuance of the London Overhead Wires Act of 1891, and we are informed that your Council, before instituting these by-laws, made enquiries at several of the leading electrical firms, and that no objection was offered to working under these regulations. We are informed, however, that many, if not all of the firms consulted, are not directly affected by these by-laws, and that another and equally important section of the electrical industry were not consulted, and they, as members of the Electrical Trade Section of this Chamber, propose that a meeting should be held for the purpose of making representations on the subject. My Council, however, recognising the courtesy which we have experienced from you in other matters, as well as in endeavouring to ascertain

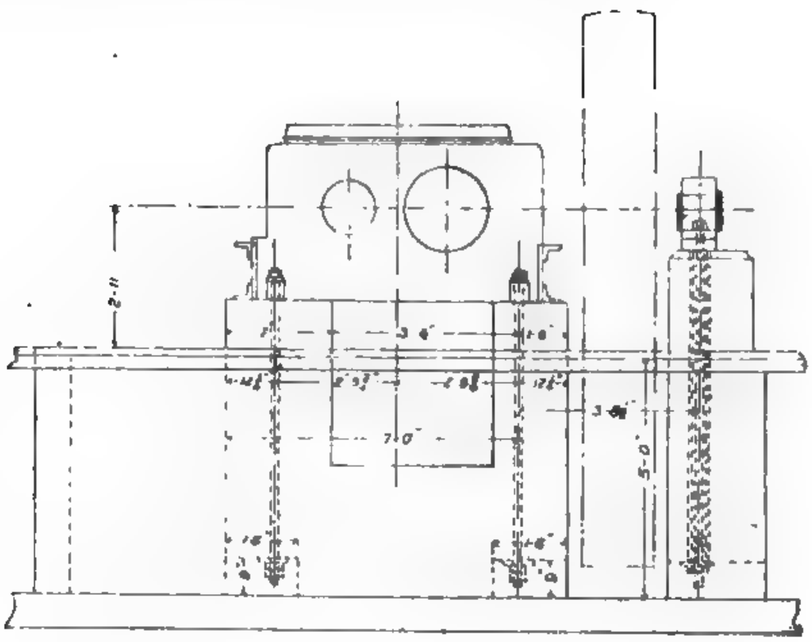
the views of many of the leading firms whom it may have been supposed were principally concerned, direct me, in the meantime, to ask you to be good enough to let us know how the matter now stands.

"I am directed at the same time to suggest that it might be well if you could forward for our information a short statement setting forth the reasons which have induced your Council to enforce these by-laws.—I am, Sir, yours faithfully, KENRIC B. MURRAY, Secretary."

FRENCH CUSTOMS TARIFF.

"To the members of the Electrical Trade Section :

"The following extracts from the new French Customs tariff as definitely passed, to come into operation on the 1st February, 1892, show the duties applicable on the articles mentioned, under the general and minimum tariff. It is understood that the latter tariff will apply to British goods :



Engine and Dynamo Foundations—Sydenham Central Station. Elevation.

"London County Council, 8th January, 1892.

"Sir,—I have to acknowledge the receipt of your letter of the 7th inst. on the subject of the by-laws made by the Council for the regulation of overhead wires.

"The information which you say has been given to the Chamber of Commerce is not quite accurate. The Council did not before making the by-laws make enquiries of the leading electrical firms and ascertain that there was no objection to working under the proposed regulations. The by-laws were made by the Council after careful consideration and consultation with its professional advisers as to what regulations appeared to be necessary for securing the public from accidents which might arise from overhead wires.

"Having made the by-laws, the Council submitted them to the Board of Trade as required by the statute, and at the request of the Board they were advertised at length in the *Times* newspaper, and a copy of them was sent to every company or person in London who appeared likely to be affected by the by-laws. If there are any persons directly concerned who have not received them it has been through want of knowledge, but inasmuch as they were, as I have stated, advertised at length in the *Times*, it was open to everyone to see them.

"The present position of the matter is this: That the Council, before making a formal application to the Board of Trade for confirmation of the by-laws, is prepared, as also is the Board of Trade, to consider any objections or observations which may be offered with regard to them by any persons interested. If, therefore, the members of your Chamber have any representations to make, they should be sent to the Council and the Board of Trade some time before the end of the month.

"With reference to your suggestion that a short statement should be sent to you of the reasons which have led the Council to make these by-laws, the best thing I can do is to refer you to the report of the Select Committee of the House of Commons on the subject in 1885, where legislation was recommended. It is upon this report that the action of the Council has been based.—I am, Sir, your obedient servant,

"H. DE LA HOOKE, clerk of the Council.

"The Secretary of the London Chamber of Commerce."

Tariff No.	Articles.	General tariff per 100 kilos. francs.	Minimum tariff per 100 kilos. francs.
361	Lampes électriques à incandescence munies de leur monture	400	350
361 *bis*	Lampes électriques à incandescence non munies de leur monture	800	700
524	Machines dynamo-électrique :		
	de 1,000 kilos, et plus	30	20
	de 50 kilos à 1,000 kilos	45	30
	de 10 kilos et pas plus de 50 kilos	100	80
536	Induits de machine dynamo-électrique et pièces détachés telles que : bobines pleines ou vides en métal entourées de cuivre isolé ; pièces travailles en cuivre, pesant moins de 1 kilo, numerotés et marquées, ajustée ensemble ou demontées, pour appareils électriques, lampes à arc dites regulateurs	100	75
575 *bis*	Accumulateurs électriques...........	17	13

"Note.—The complete official text of the tariff law may be seen in the reading-room of the London Chamber of Commerce.

"January 15th, 1892."

"CRYSTAL PALACE EXHIBITION AND RAILWAY RATES.

"Dear Sir,—This Chamber recently approached the London Brighton, and South Coast and the London, Chatham, and Dover Railway Companies with a view of securing a reduced rate on exhibits intended for the Electrical Exhibition at the Crystal Palace. The companies did not see their way, however, to grant reduced rates ; but I am now in receipt of two letters, copies of which I enclose, from which you will see that the companies have agreed to convey the unsold exhibits, on the return journey, free of charge to any station on either of these lines of railway, provided that the exhibits remain the property of the exhibitors.—Yours faithfully, KENRIC B. MURRAY, Secretary.

"January 13th, 1892."

[COPY.]

"London, Brighton, and South Coast Railway,
"London Bridge, S.E.,
"11th January, 1892.

"ELECTRICAL EXHIBITION AT CRYSTAL PALACE, 1892.

"Dear Sir,—Adverting to my letter to you of the 28th ulto., I have the pleasure to inform you that, although we do

not see our way to meet your wishes with regard to making a reduction in the rail-charge for the conveyance of the exhibits to the Crystal Palace, we shall nevertheless be willing to assist the exhibitors in this respect by conveying the unsold exhibits on the return journey from the Crystal Palace back to the station whence they were sent free of charge at owners' risk.

"This concession relates, of course, to traffic from and to our own stations only, and does not in any way affect or disturb the terms and arrangements concerning traffic to places on other companies' lines.

"I should be glad if you would be good enough to notify your Council accordingly.—I am, dear Sir, yours faithfully,

"N. SARLE, Secretary and General Manager."

"London, Chatham, and Dover Railway Company,
"Manager's Office, Victoria Station,
"9th January, 1892.

"Dear Sir,—In reply to your letter of the 15th ulto., I have the pleasure to inform you that, after due consideration, it has been arranged by this company and by the L. B. and S. C. Company for exhibits which were originally sent from stations on our respective systems to be conveyed on the return journey free of charge at owners' risk, providing they remain the property of the exhibitors.—I am, dear Sir, yours truly,

"JOHN S. BATES."

MODERN APPLICATIONS OF ELECTRICITY TO METALLURGY.*

BY G. C. V. HOLMES, SEC.I.N.A.

During the last few years the application of electricity to lighting and to motive power has received the greatest attention from the engineering profession, but comparatively little notice has been taken of the equally important application of this force to metallurgy and the manufacture of metal goods. At the present moment, however, the manufacture of copper goods by electrical methods is beginning to excite considerable attention in the engineering world because of the extraordinary facility with which such articles as sheets, tubes, rollers, wire and tape for electric lighting and telegraphic purposes, etc., can be produced in one operation and of qualities hitherto unattainable. The author hopes, therefore, that a paper on this subject will prove of interest to the society, and as it will probably be considered more satisfactory, instead of giving a mere description of the methods and apparatus actually used in producing the results which have been attained, he proposes to commence by referring briefly to the electro-chemical principles of the subject, then to go on to show how these principles have been applied to that large and important industry—the electric refining of copper—and finally give an account of the methods by which, during the process of the refining of the copper, finished goods, such as those above enumerated, can be automatically produced of absolutely pure metal.

Electro-Chemical Principles.—It was discovered in the first year of the present century that water could be decomposed into its chemical constituents by passing through it an electrical current of sufficient tension. The process is known as electrolysis; the ends of the conductors are called electrodes, that by which the current enters the waters is called the anode, and the end of the other conductor by which the current passes out again is called the cathode. At the surface of the anode, oxygen gas is separated from the water, while at the surface of the cathode hydrogen is formed, each gas being separated exactly in the proportions required to form water. The atoms which are decomposed, or electrolysed, are called in electro-technical language, ions; those which appear at the anode and cathode being named respectively, anions and kathions.

There are three principal laws which express the quantity of action which takes place during the electrolytic process. These laws are of the utmost practical importance to enable the cost of the operation to be ascertained. They are as follows:

I.—The amount of chemical action is equal at all points of a circuit. For instance, if the current were passed through a series of vessels, connected by a series of conductors, the ends of each of which were immersed in the water of two adjacent vessels, the first and last conductors being connected respectively with the positive and negative poles of the source of electricity, so that the whole formed one continuous circuit, then the amount of water decomposed in each vessel in the circuit would be equal.

II.—The amount of the chemical action which takes place in a given time is exactly proportional to the quantity of the current which passes through the vessel. For instance, a current of six amperes would decompose three times the quantity of water in each vessel which a current of two amperes would separate in the same time.

III.—The amount of hydrogen liberated by the passage of a current of one ampere through water during one second is ·000015 gramme. This quantity is called the electro-chemical equivalent of hydrogen. The amount of any other chemical element liberated at an electrode by the passage of a current of electricity of one ampere during one second through any other solution, containing the chemical element in a form in which it can be electrolysed, is exactly equal to the electro-chemical equivalent of hydrogen multiplied by the chemical equivalent of the element in question. Thus the chemical equivalent of oxygen is 8, and the weight of oxygen liberated by the above-mentioned current in a vessel of water would be $\cdot0000105 \times 8 \doteq \cdot0000840$, which number is therefore its electro-chemical equivalent. Below is given a table of the atomic weights and electro-chemical equivalents of the principal elements which have to be considered in electrolytic work.

TABLE I.

Name of element.	Atomic weight.	Chemical equivalent.	Electro-chemical equivalent in grammes per ampere-second.
Hydrogen	1·0	1·0	·0000105
Potassium	39·1	39·1	·0004105
Sodium	23·0	23·0	·0002415
Gold	196·6	65·5	·0006875
Silver	108·0	108·0	·0011340
Copper	63·0	31·5	·0003307
Mercury	200·0	100·0	·0010500
Tin	118·0	29·5	·0003097
Iron	56·0	14·0	·0001470
Nickel	59·0	29·5	·0003097
Zinc	65·0	32·5	·0003412
Lead	207·0	103·5	·0010867
Oxygen	16·0	8·0	·0000840
Chlorine	35.50	35·5	·0003727
Nitrogen	14 00	4·3	·0000490

Nothing has yet been said regarding the energy required to effect the decomposition. Taking, again, the case of water. . As soon as the smallest quantities of oxygen and hydrogen appear at the anode and cathode respectively, the apparatus is converted into a secondary battery, the elements of which—viz., the two above-named gases—tend to combine, and in so doing develope an E.M.F. of 1·45 volts. The current employed to effect the decomposition must therefore possess at least an equal E.M.F., and in addition whatever E.M.F. is necessary in order to overcome the electrical resistance of the generator of electricity, the conductors, and the liquid between the anode and cathode.

If Q be the quantity of electricity passing through the circuit, E the back E.M.F., E^1 the E.M.F. necessary to convey the current through the above-named resistances, then the work done by the current $= Q\,(E + E^1)$.

The E.M.F. of any particular chemical reaction is equal to the product of the electro-chemical equivalent of the separated ion into its heat of combination when entering into the combination in question expressed in dynamical units. For explanation of this reference is made to the work on "Electricity and Magnetism," written by our distinguished past-president, Prof. Silvanus Thompson, F.R.S.

The above law is expressed as a formula as follows: Let E be the E.M.F. in volts; Z, the electro-chemical equivalent of the separated ion; H, the number of units of heat evolved by a gramme of the substance when entering into the combination; and J, Joule's equivalent (42×10^6), then $E = Z\,H\,J$.

Taking as an illustration the case of copper dissolving into sulphuric acid, from the above table $Z = \cdot003307$, $H = 881$, $J = 42 \times 10^8$, then $E = \cdot003307 \times 881 \times 42 \times 10^8 = 1{\cdot}223 \times 10^8$ "absolute" units of E.M.F. = 1·223 volts.

To consider next the case of the electrolysis of sulphate of copper solution with an insoluble anode such as platinum. The chemical expression of this combination of copper, sulphur, and oxygen is $CuSO_4$, which differs from sulphuric acid (H_2SO_4) in that the two atoms of hydrogen are replaced by one atom of copper.

When the current of sufficient E.M.F. is passed through a solution of this salt in water the $CuSO_4$ is split up into Cu, or metallic copper, which is deposited on the cathode, and SO_4, which decomposes the water of the solution, forming sulphuric acid and free oxygen.

Thus:
$$CuSO_4 = Cu + SO_4$$
$$SO_4 + H_2O = H_2SO_4 + O.$$

The result is in the end the same if it is supposed that the current in the first instance decomposes the water of the solution. In this case, as before, oxygen appears at the anode and hydrogen at the cathode. The free hydrogen, however, at once decomposes the sulphate of copper, replacing the copper, which latter is deposited in the metallic form on the cathode. If the current is passed for a sufficiently long time through the solu-

* Paper read before the Junior Engineering Society, Jan. 15.

tion, the whole of the copper will be extracted from the salt and will be deposited, and the solution itself will be converted into dilute sulphuric acid. The minimum work done in effecting the decomposition expressed in watts is equal to the current expressed in amperes multiplied by the back E.M.F. in volts of copper entering into combination with sulphuric acid. This E.M.F. has been shown above to be 1·223 volts, and if Q amperes be the quantity of electricity passing per minute, then $Q \times 1{\cdot}223$ watts per minute is the minimum energy required to effect the decomposition, to which has to be added the energy required to overcome the resistances of the generator of electricity, the conductors, and the electrolyte.

The author lays stress upon these elementary facts in order to pave the way, in a systematic manner, to ascertaining the commercial cost of refining rough copper.

Coming next to the case of electrolysing the same sulphate of copper solution, but employing an anode of pure copper instead of the insoluble anode of platinum taken in the last instance. In this case we may suppose, as before, that copper is deposited on the cathode and oxygen liberated at the anode, while part of the solution is turned into sulphuric acid. The nascent oxygen, however, combines with the copper of the anode, forming oxide of copper, which latter immediately dissolves into the sulphuric acid present, re-forming sulphate of copper and liberating an equivalent amount of water. Thus, everything is restored to its first condition, and the process goes on continuously; copper being deposited from the solution on to the cathode, while it is dissolved in precisely equal quantities from the anode, and the solution, instead of being converted into dilute sulphuric acid, as in the first case, is constantly replenished with copper, and is maintained as a solution of the sulphate of that metal, and serves, in fact, as the medium for transmitting the metal of the anode to the cathode. Thus we see that whatever chemical changes occur at one part of the combination precisely opposite changes occur at another part, and consequently no work whatever is done in the purely chemical part of the operation; and if the solution, the conductors, and the electric generator had no resistance—that is, were of perfect conductivity—then an electric current of infinitely small E.M.F. would effect the deposition. The same facts may be put in another way by stating that there is no back E.M.F. in the bath, because the nascent oxygen liberated at the anode, instead of tending to combine with the deposited copper on the opposite cathode—thus forming an electric couple—combines at once with the copper of the anode with which it is in contact, while the energy of the combination is balanced by the simultaneous absorption of energy due to the decomposition of the metal at the cathode.

This elementary fact, which is perfectly well known to those who have conducted the simplest experiment in copper plating, is the sole secret of the extraordinary cheapness of the process of the electro-refining of copper. In practice, of course, the generator, the conductors, the electrodes, and the solution offer a definite, even if very small, resistance to the passage of the current, and the current must have a corresponding E.M.F. in order to overcome these resistances, but it must be definitely understood that in electroplating copper from a pure copper anode the overcoming of this imperfect conductivity is the sole work done by the current, the energy employed in doing chemical work being nil.

It may here be mentioned that in order to promote free action, and in order to improve the conductivity of the electrolyte, a certain amount of free sulphuric acid is always put into the bath along with the water and the copper salt, and consequently, if there is a considerable inequality between the areas of anode and cathode, more or less copper may be dissolved into the solution than is deposited on the anode, according to which area predominates, and consequently the liquid may vary in richness of salt during the time the current is passing.

The case of depositing the metal from an impure copper anode introduces at once the metallurgical industry of refining raw copper. The rough copper of commerce is usually alloyed or mixed with various other metals, and there is no immediate apparent reason why they should not be dissolved by the action of the current into the free sulphuric acid present in the solution in the bath and deposited together with the copper on the cathode. It will be presently seen, however, that with ordinary precautions such action does not take place, but that the copper is deposited in a pure state.

When an anode is composed of a mixture or an alloy of several metals, and the electric current passed through, the various component metals are not oxidised and dissolved simultaneously. They are, on the contrary, attacked in a certain order depending upon the energy which they develop when combining with oxygen and dissolving into the acid of the solution. The metal which is attacked first is that which by its oxidation developes the greatest energy, or which, if used as one of the elements of a primary battery, would develop the highest E.M.F.; and so on in regular order. *Vice versâ.* When several metals are simultaneously in solution in the bath the order of deposition is the reverse of the order of dissolution—that is to say, that metal will be first deposited the separation of which from the solution requires the least amount of energy. This law, the author believes, was first stated by Dr. Kiliani, of Munich, and was published in the German "Bergen Hütten Münnische Zeitung" in the year 1885.

The subject-matter of this law is a very large one, and whether its application to all the metals found in combination with rough copper has been fully studied is a matter of very much doubt. Concerning a few of the metals, such as silver, lead, iron, copper, and zinc, however, when dissolved into and deposited from a few electrolytes, pretty extensive researches have been made. The following are some of the principal metals found in combination with copper: Manganese, zinc, iron, tin, cadmium, cobalt, nickel, lead, arsenic, bismuth, antimony, copper, silver, gold. They are given in the order of the heats of combination developed by them when undergoing oxidation. The list therefore also gives the order in which they would be dissolved according to Dr. Kiliani's law; while if in solution they would be deposited in the inverse order.

It will be noted that copper comes almost at the bottom of the list, having only the precious metals silver and gold below it. It is largely to this circumstance that is due the facility with which copper can be refined, for under the ordinary circumstance of deposition neither the gold nor the silver oxidise and dissolve into the electrolyte at all, but fall to the bottom of the bath in the shape of metallic powder when the surrounding metals in which they are embedded dissolve away; hence the copper is left as the metal most easily separated from the solution, and in accordance with the law previously stated it is deposited on the cathode before any of the other metals, all of which are oxidised and some dissolved into the solution before it. It must, however, be acknowledged that the above statements are only true and the law applicable so long as certain conditions relating to the strength and E.M.F. of the current, the composition of the electrolyte, and the proportion of the foreign metals in the anode are observed.

As an instance of some of the variations that occur, it may be stated that if the E.M.F. of the current exceed a certain degree several of the metals may be dissolved and deposited simultaneously. This peculiarity is obviously due to the fact that, when they dissolve into the solution, each metal can be electrolysed by a current having an E.M.F. somewhat higher than the natural E.M.F. due to the combination of the metal with the acid of the bath. (See the case of the electrolysis of sulphate of copper between insoluble anodes.) If, then, the electrolyte contained several metals in solution and the E.M.F. of the current were gradually increased, each of them would, in turn, be separated from the solution and deposited. If, on the other hand, the E.M.F. at the outset were higher than the highest natural E.M.F. which could be developed by any metal present entering into the combination in question, then all of them would simultaneously be separated and deposited. If the current density per unit of area of cathode exceed a certain amount (approximately five amperes per square foot of surface) the copper will not be deposited in the metallic form at all, but will fall to the bottom of the bath in the shape of powder. The composition of the electrolyte—*i.e.*, the proportions of free acid, copper sulphate, and water—exercises an important influence on the character of the deposit, as also does the temperature. The more neutral and the poorer in dissolved copper the electrolyte, the more easily will the metals low down in the above list be dissolved, and the more easily also will those high up in it be deposited. The precise reasons for some of the above peculiarities have never been exactly ascertained, and hence it comes that the practice of the electrolytic refining of copper, though reposing in the main on well-ascertained scientific principles, involves the knowledge and use of so many expedients and precautions that it is by no means the easy and straightforward work which might be supposed.

In addition to the metals themselves, the oxides and sulphides of some of them may be present in the anodes, and some oxides which cause difficulties are formed by the action of the current. Those, for instance, of lead and tin are insoluble in sulphuric acid. Others dissolve but slowly, and while they remain on the surface of the anodes they will act precisely as the lead peroxide does in a secondary battery—that is to say, they will form with the copper on the cathode a more or less powerful electric couple, the E.M.F. of which acts in the opposite direction to that of the current. Hence, the current must in such circumstances have an E.M.F. sufficient to overcome this back force, in addition to being able to overcome the resistances of the generator, conductors, and electrolyte, and the cost of the deposition will be proportionately increased. In practice, however, with anode of the degree of purity generally used for electrofining this back E.M.F. is not considerable, as the whole E.M.F. required to overcome all the conductive resistances and the back force varies according to the current density used, between a quarter and half a volt per tank. It should, however, be mentioned that the oxides being relatively non-conductors, if the position of the anode in the bath be such that they accumulate on the surface of the latter and cannot escape, the conductive resistance may be considerably increased. This is a point of considerable importance for two reasons: first, the

increase in the resistance increases the cost of the electric current; and, second, owing to the increased E.M.F. necessary to move a given current through the circuit, the deposition of the other metals which may have been dissolved into the electrolyte is facilitated and the refining action of the current correspondingly diminished.

Copper-refining Apparatus.—The practical apparatus required to refine rough copper electrolytically is of the simplest kind. A boiler, steam engine, and dynamo are of course indispensable. What the electrical output of the latter shall be is of course determined by the surface of anodes which it is intended to expose in any one tank or bath, the usual allowance being a current of between four and five amperes per square foot of surface. The E.M.F. of the current depends upon the number of tanks which it is intended to work in series—*i.e.*, through which it is intended to drive the current—and also on the average of the combined resistances per tank. With a well-arranged plant the difference of potential between the anode and the cathode of each tank should be considerably less than half a volt. The tanks are generally made of wood and measure about 3ft. in each direction. They are rendered acid-proof by being lined with lead, or some composition into which pitch enters largely. It is of the utmost importance that the tanks should be perfectly acid-proof, not only in order to avoid loss of the electrolyte by leakage, but also to ensure the electrical insulation; for the sulphate of copper solution, containing as it does free sulphuric acid, is a very good conductor, and if the floors in the neighbourhood of the tanks got to be saturated with it a considerable proportion of the current would be lost to earth. On the tops of the sides of the tanks at front and back are placed strips of copper, which serve as conductors, and which are alternately connected. The anodes are square plates of cast rough copper, the tops of which are in contact with rods of the same metal, which rest on the two conductors, that end which rests on the conductor which conveys the current to the next tank being, of course, insulated. The cathodes are sheets of thin copper similarly resting on the conductors, only in this case the ends reposing on the other conductors are insulated. Several anodes and cathodes are hung parallel to each other in each tank, and when a sufficient thickness of electrolytic copper is deposited on the cathodes they are removed from the bath and the deposited layer is easily split away from the original cathode, which remains intact and ready for fresh use. The thickness of the deposited copper on the cathode is a matter principally affected by the capital at the disposal of the firm for locking up in raw material. The electrolyte is formed by dissolving 2lb. of sulphate of copper to each gallon of water and adding 8oz. of concentrated sulphuric acid. The aim of the refiner is to procure a supply of rough copper containing a good proportion of gold and silver. Many brands of copper are exceedingly rich in the precious metals, and it is usual to allow a certain proportion of the assay value free to customers.

Cost of the Process.—The cost of the operation of refining copper is determined mainly by the difference of potential between the anodes and cathodes in each tank. The lower the latter, of course the less cost. It has been shown that with a pure anode only sufficient E.M.F. has to be provided to overcome the ordinary resistances, while with an impure anode an additional difference in potential is required to overcome the back E.M.F. due to the accumulation of oxides on the anode, and a portion of the energy of the current is of course absorbed in oxidising the foreign metals present. It so happens that while it is easy by the old methods to refine rough copper up to, say, 98 per cent., it is very difficult by these methods to get it still purer. By the electrolytic methods, on the contrary, it is much easier to take the last impurities out than it is to refine a really rough copper. Thus, the two methods may be said to be complimentary to each other, and in practice it is desirable to bring the metals by the older methods up to such a state that only about 2 to 3 per cent. of impurities remain in it. The principal resistance to conductivity is in the electrolyte itself. This resistance can be diminished by reducing the length of liquid which the current has to traverse and by increasing its cross-section—that is to say, by bringing anode and cathode as close together as is found to be practicable and by exposing as large an area as possible.

(To be continued.)

COMPANIES' REPORTS.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY.

Directors: Eustace J. A. Balfour, Esq. (chairman), H. Woodburn Kirby, Esq. (vice-chairman), Latimer Clark, Esq., F.R.S., Egerton H. Clarke, Esq., Sir John H Morris, K.C.S.I., Charles Showell, Esq. General manager and secretary: Frederic J. Walker. Chief engineer: S. T. Dobson, A.M.I.C.E., M.I.E.E.

Report of the Directors and statement of accounts for the year ending 31st December, 1891, to be presented to the shareholders at the ordinary general meeting to be held at the St. James's Hall Restaurant on Tuesday next, at 3 p.m.

The Directors in submitting their annual report for 1891, with accounts as certified by the Company's auditors, congratulate the shareholders on the satisfactory progress made by the Company during the past year. Early in 1891 the capital of the Company was increased from £100,000 to £200,000 by special resolution of the shareholders, creating 20,000 7 per cent. preference shares of £5 each. Of these shares 10,000 were issued to the shareholders at par, and fully subscribed for by them in March. The balance of 10,000 shares was issued in December last at 30s. per share premium, and duly allotted to the shareholders. This last issue of shares placed £15,000 at the disposal of the Directors as a capital reserve fund. The £15,000 has since been invested in 2¾ per cent. annuities, and is shown in the accounts annexed hereto. The attention of the Directors has been largely directed during the year to the purchase of land for, and the erection of, a northern station. Owing to the congested condition of the parish and the extreme scarcity of available ground this proved to be a difficult matter. The Directors, however, are pleased to be able to report that they have secured a suitable freehold site in Carnaby-street, Regent-street, and have entered into a contract for the erection of the building on designs prepared by Mr. C. Stanley Peach, F.R.I.B.A. A considerable portion of the machinery and boilers required for this station have also been constructed, and it is hoped that during the summer of this year the station will be finished and in working order. There are certain compulsory mains which have to be laid in the parish before August next. These, with other mains which the Board deem necessary to complete the system, will be proceeded with without loss of time, and there seems every reasonable probability of the whole of the work being completed without any further capital being required. It may be of interest to the shareholders to know that the two stations will be connected by a grand trunk main, about half of which is already completed and laid. This will be a means of enabling the northern station to support the southern in case of necessity, and *vice versâ*. The system adopted by the Company has worked thoroughly well during the whole of the year, and the Directors are satisfied that it is the best that could be selected having regard to present knowledge. The experience gained at the Company's works enables the Company's officials to make improvements from time to time, and no precaution is neglected to maintain the excellent results hitherto obtained. The net earnings of the Company during the past year have amounted to £10,395. 12s. 5d. Of this sum £3,610. 6s. 4d. was distributed in July last in payment of an interim dividend at the rate of 7 per cent. per annum for the half-year ending June 30, 1891, on the ordinary shares, and on the instalments paid on the first issue of preference shares. The balance of £6,785. 6s. 1d., added to £315. 12s. 9d. (the undivided profit from last year's account), leaves £7,100. 18s. 10d. now to be dealt with. The Directors propose to divide this amount as follows—viz.:

	£	s.	d.
(A) By payment of a dividend at the rate of 7 per cent. per annum calculated on the instalments paid on the first issue of 10,000 preference shares for the second half of the year	£1,333	6	8
(B) By payment of a dividend at the rate of 10 per cent. per annum for the second half-year on the ordinary shares, making, with the interim dividend paid in July last, a total distribution of 8½ per cent. for the year	4,670	0	0
(C) By paying a dividend of £10. 15s. per share on the founders' shares	1,075	0	0
(D) Amount to be carried forward to ordinary shareholders' undivided profit account	6	2	6
(E) Amount to be carried forward to founders' undivided profit account	16	9	8
	£7,100	18	10

The Directors have carried £1,000 to redemption account to commence a fund, to accumulate by annual additions, to represent loss of capital at the expiration of the term covered by the provisional order. The Directors are advised that the amounts provided in the accounts for depreciation are sufficient and ample for all purposes. Two of the directors—namely, Messrs. Egerton H. Clarke and H. Woodburn Kirby retire under Clause 79 of the articles of association, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., also retire, and, being eligible, offer themselves for re-election.

NET REVENUE ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1891.

Dr.	£	s.	d.	£	s.	d.
Interest on debentures	325	0	0			
Interest on calls in advance	71	18	8			
				396	18	8
Balance, being net profits applicable to dividends on shares				10,711	5	2
				£11,108	3	10

Cr.	£	s.	d.	£	s.	d.
Balance from last account	2,565	12	9			
Less dividend (5 per cent. paid on ordinary shares, free of income tax)	2,250	0	0			
				315	12	9
Balance from revenue account No. IV				10,502	6	10
Interest on money at deposit				290	4	3
				£11,108	3	10

STATEMENT OF SHARE CAPITAL ON 31ST DECEMBER, 1891.

Description of capital.	Authorised by.	Number of shares issued.	Nominal amount of share.	Called up per share.	Total paid up.	Issued, not paid up.	Remaining unissued.	Total amount authorised.
			£	£	£	£	Shares	£
£99,900, divided into 19,980 ordinary shares of £5 each	Memorandum of association	18,680	5	5	93,400	Nil	1,300	99,900
£100,000, divided into 20,000 preference shares of £5 each	Special resolution, 20th March, 1891	20,000	5	£5 on 10,000; 10s. on 10,000	55,000	45,000	Nil	100,000
£100, divided into 100 founders' shares of £1 each	Memorandum of association	100	1	1	100	Nil	Nil	100
		38,780			148,500	45,000	1,300	200,000

STATEMENT OF LOAN CAPITAL ON 31ST DECEMBER, 1891.

Description of loan.	Amount borrowed. At 6 per cent.	Amount borrowed. Total.	Remaining borrowing powers.	Total amount of borrowing powers.
	£	£	£	
Six per cent. mortgage debentures	6,500	6,500	93,500	One-half the nominal capital of the Company for the time being.

To share capital paid up, see No. I., £148,500. Total loan capital borrowed, see No. II., £6,500. Total capital received, £155,000.

CAPITAL ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1891.

Dr.	Expenditure up to 31st Dec., 1890. £ s. d.	Expended during the year. £ s. d.	Total expenditure up to 31st Dec., 1891. £ s. d.
Land (including law charges incidental to acquisition)	9,598 0 8	20,297 7 8	29,895 8 4
Buildings and paving	11,186 0 7	1,958 14 11	13,144 15 6
Machinery and plant	27,905 6 4	12,056 11 11	39,961 18 3
Accumulators	1,596 5 5	23 7 11	1,619 13 4
Mains, including cost of laying	28,631 11 1	9,531 10 7	38,163 1 8
Meters fixed on installations	1,578 19 0	1,271 18 2	2,850 17 2
Switches fixed on installations	700 0 3	544 2 0	1,244 2 3
Stores and labour used on installations	1,172 19 7	883 9 1	2,056 8 8
Electrical instruments, etc.	256 0 6	106 9 1	362 9 7
Patent rights	—	30 0 0	30 0 0
Cost of license and provisional order	705 10 2	—	705 10 2
Sinking artesian well	668 2 6	286 17 6	955 0 0
Office and other furniture and fittings	510 1 5	207 3 2	717 4 7
Compensation	392 13 10	—	392 13 10
Expenses connected with Board of Trade enquiry	152 8 7	—	152 8 7
Preliminary expenses	920 1 11	105 10 0	1,025 11 11
Expenses of debenture issue	275 7 4	—	275 7 4
Law and parliamentary expenses	539 19 6	28 1 9	568 1 3
Management, general expenses and interest to 31st December, 1889, less receipts	5,337 9 6	—	5,337 9 6
	£92,126 18 2	47,331 3 9	139,458 1 11
Balance of capital account			15,541 18 1
			£155,000 0 0

Cr.	Receipts up to Dec. 31, 1890. £ s. d.	Received during the year. £ s. d.	Total receipts to Dec. 31, 1891. £ s. d.
Ordinary shares, 18,680 of £5 each	44,880 0 0	48,520 0 0	93,400 0 0
Preference shares 10,000 of £5 each, fully paid	—	50,000 0 0	50,000 0 0
Preference shares 10,000 of £5 each, 10s. paid	—	5,000 0 0	5,000 0 0
Founders' shares, 100 of £1	100 0 0	—	100 0 0
6 per cent. mortgage debentures	50,000 0 0	—	—
Less converted into ordinary shares during 1891	43,500 0 0	—	6,500 0 0
			£155,000 0 0

REVENUE ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1891.

Dr.		£ s. d.	£ s. d.
A.—To Generation and Distribution of Electricity.			
Coal and other fuel, including dues, carriage, etc.		4,668 8 3	
Oil, waste, water, and engine-room stores		771 17 2	
Salaries of engineers and officers		609 12 6	
Wages at generating and distributing stations		2,835 2 0	
Repairs, maintenance, and renewals, as follows:			
1. Buildings	£562 8 2		
2. Engine and boilers	669 3 8		
3. Dynamos	186 14 2		
4. Other machinery, instruments, and tools	145 0 6		
5. Accumulators	4 13 10		
6. Lamps (at station)	134 4 1		
		1,702 4 5	
Repairs, maintenance, and renewals of mains		527 15 6	
Miscellaneous expenses		72 13 4	
			11,187 13 2
B.—To Rents, Rates, and Taxes.			
Rents payable		419 2 9	
Rates and taxes		360 14 10	
			779 17 7
C.—To Management Expenses.			
Directors' remuneration		1,155 1 5	
Salaries of general manager and secretary, engineer, clerks, etc.		1,816 0 3	
Stationery, printing, and advertising		353 6 0	
General establishment charges		247 2 5	
Auditors of Company		52 10 0	
			3,624 0 1
D.—To Law and Parliamentary Charges.			
Law expenses			558 14 7
E.—To Special Charges.			
Insurance		158 13 8	
Brokerage on shares		14 1 0	
			172 14
F.—To Depreciation.			
Depreciation on buildings		285 8 10	
Depreciation on plant, machinery, etc.		3,727 19 1	
			4,013 7 11
G.—To Redemption Fund.			
Provision for recoupment of capital expenditure			1,000 0 0
			21,336 8 0
Balance carried to net revenue account			10,562 6 10
			£31,898 14 10

Cr.	£ s. d.
Sale of current, after deducting provision for bad and doubtful debts	30,934 14 4
Sale of current under contracts	215 3 6
Rental of meters on consumers' premises	362 2 11
Rents receivable	100 0 0
Transfer fees	117 9 6
Discounts on purchases	134 14 9
Sale of old materials, stores, etc.	34 9 10
	£31,898 14 10

Dr. Capital Reserve Fund.	£	s.	d.
Balance	15,000	0	0
Cr.	£	s.	d.
Premium of £1. 10s per share on issue of 10,000 preference shares in December, 1891	15,000	0	0

Dr. Depreciation Fund.	£	s.	d.
Balance	5,819	19	5
	£5,819	19	5
Cr.	£	s.	d.
Balance from last account, December 31, 1890	1,806	11	6
Amount brought from revenue account No. IV.	4,013	7	11
	£5,819	19	5

Dr. Redemption Fund.	£	s.	d.
Balance	1,000	0	0
Cr.	£	s.	d.
Amount brought from revenue account No. IV.	1,000	0	0

General Balance-sheet, 31st December, 1891.

Dr.				£	s.	d.
Capital account—						
Amount received as per account No. III.				155,000	0	0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc.				902	10	2
Sundry creditors on open accounts				1,065	5	11
Shareholders—for calls paid in advance—(due 1st January, 1892)				9,451	16	8
Unclaimed dividends				0	11	2
Capital reserve fund				15,000	0	0
Depreciation fund				5,819	19	5
Redemption fund				1,000	0	0
Net revenue account—						
Balance at credit thereof	£10,711	5	2			
Less interim dividends paid on ordinary and preference shares.	3,610	6	4			
				7,100	18	10
				£195,341	2	2
Cr.				£	s.	d.
Capital account—amount expended for works, as per account No. III				139,458	1	11
Stores on hand—						
Coal	£724	0	0			
Lamps	32	15	7			
Meters and switches	103	19	8			
General, including oil, waste, etc.	1,360	0	9			
				2,220	16	0
Sundry debtors for current supplied	9,852	13	3			
Other debtors	54	0	6			
				9,906	13	9
Cash at bankers (Lloyd's Bank, Limited), including deposit of £27,000	28,726	8	1			
Cash in hand	29	2	5			
				28,755	10	6
Capital reserve fund investments, 2½ per cent. annuities				15,000	0	0
				£195,341	2	2

COMPANIES' MEETINGS.

DIRECT UNITED STATES CABLE COMPANY.

The twenty-ninth ordinary general meeting of this Company was held at Winchester House on Friday, the chairman, Sir John Pender, K.C.M.G., presiding.

Having referred in sympathetic terms to the death of the Duke of Clarence, the **Chairman** said that the revenue for the half-year ended the 31st ult., after deducting the out-payments, had been £45,402, while the working and other expenses, including income tax, but excluding the cost of repairs, had absorbed £17,673, leaving a balance of £27,729 as the net profit of the half-year, which was increased by the amount brought forward to £31,231. Interim dividends of 3s. 6d. a share had been paid for the quarter ended September 30 last, and for the quarter ended the 31st ult., £5,000 had been added to the reserve fund, and a balance of £4,983 had been carried forward. The revenue showed an increase of £2,055 compared with that of the corresponding period of last year. The M'Kinley tariff had no doubt restricted trade in many quarters, and but for the large operations in grain owing to the deficient harvest in Europe, the revenue of the Company would probably have shown a falling off. The reserve fund account had been charged with £4,478 for the cost of repairs of cable, but it had been credited with £4,303 interest on investments, and with £5,000 from the revenue account, increasing the balance of the reserve account to £259,680. There was no doubt that the preparations for next year's great exhibition would benefit their revenue, but until such a growth of telegraphy came as to fully employ all the cables in the Atlantic they did not think they could look forward to any very large increase in their returns. During the past six months they had had to effect one repair in their cables, and in carrying out this work they took up a portion of the cable, which was in such a condition as to satisfy them that although it was 17 years old, it had a considerable number of years of life in it yet. He moved the adoption of the report.

This was seconded by **Mr. Wm. Ford**, and carried unanimously.

NEW COMPANIES REGISTERED.

Metropolitan Light Company, Limited.—Registered by J. Hands, 15, Old Jewry-chambers, with a capital of £5,000 in £1 shares. Object: to acquire the undertaking of D. C. Defries, now carried on at 43 and 44, Holborn-viaduct, under the style of the Metropolitan Light Company, in accordance with an agreement made between D. C. Defries of the one part and this Company of the other part, and generally to carry on business as gas, electrical, and general engineers. There shall not be less than three nor more than five Directors. The first to be appointed by D. C. Defries. Qualification: D. C. Defries, as managing director, £1,000; ordinary Directors, £500.

BUSINESS NOTES.

West India and Panama Telegraph Company.—The receipts for the half-month ended January 15 were £2,331, against £2,791.

St. James's and Pall Mall Company.—The Directors recommend a dividend at the rate of 10 per cent. per annum on the ordinary shares for the half-year ended December 31, 1891.

National Telephone Company.—The Directors have unanimously elected Mr. James Staats Forbes, one of the vice-presidents, as president of the Company, in succession to the late Mr. Frederick Richards Leyland.

City and South London Railway.—The receipts for the week ending 17th inst. were £836, against £765 for the corresponding week of last year, showing an increase of £71. As compared with the week ending Jan. 10th, the receipts show a decrease of £22.

Electric Contractors.—An electrical department has been added to the business of Messrs. H. Turner and Son, ironmongers and cutlers, 28, Villiers-street, Strand, W.C. Messrs. H. Turner and Son announce themselves prepared to submit estimates for electrical work of every description, especially electric lighting and wiring.

Brush Electrical Engineering Company.—The Directors have declared an interim dividend upon both the ordinary and preference shares of the Company at the rate of 6 per cent. per annum for the six months ended 31st December last, payable on the 15th February next. The transfer-books of the Company will be closed from the 20th to the 27th inst.

Laing, Wharton, and Down.—With regard to the recent removal of the offices of the Laing, Wharton, and Down Construction Syndicate, Limited, to 38, Parliament-street, Westminster, this change in no way relates to the old-established firm of Messrs. Laing, Wharton, and Down, whose address remains 82A, New Bond-street, W., with the addition of branch and City offices at 17, Gracechurch-street.

The Anglo-American Telegraph Company recommend a balance dividend of 16s. per cent. on the ordinary consolidated stock for the year ending December 31, and balance dividend of £1. 12s. per cent. upon the preferred stock for the year ending December 31, both payable on January 30, less income tax, to the stockholders registered on the books on the 12th inst. After paying the foregoing dividends there will be a balance of £864 to be carried forward. The above dividends, together with those already paid, will amount to £2. 12s. 6d. per cent. on the ordinary and £5. 5s. per cent. on the preferred stocks for the year 1891.

City of London Electric Lighting Company.—In fulfilment of the pledge given at the statutory meeting, that shareholders should have the first offer of the unissued 9,848 ordinary shares in the Company, the Directors have decided to allot the whole of these *pro rata* to shareholders on the register on January 14th. A circular has therefore been issued by Mr. J. Cecil Bull, secretary, offering shareholders shares at the rate of as nearly as possible one for every three held, at 5s. premium. The first payment of £3. 5s. per share will be due to-morrow (Saturday), and if not paid by then the allotment will be forfeited. After the second payment of £3 per share on February 1st next, the shares now allotted will rank *pari passu* in all respects with existing shares.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3⅜
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5½
Metropolitan Electric Supply	—	10
London Electric Supply	5	1⅜
Swan United	3½	4½
St. James'	—	8⅞
National Telephone	5	4½
Electric Construction	10	6⅜
Westminster Electric	—	6⅝
Liverpool Electric Supply	5	5
	3	2⅞

NOTES.

Church Lighting.—The electric light has been installed at All Saints' Church, Southampton.

Austria.—An electrical tramway is contemplated in Austria between Mähuish-Oshan and Prziwos.

Crystal Palace.—The visit of the Lord Mayor and Lady Mayoress to the Electrical Exhibition will take place on 6th February.

St. Petersburg.—The electrical exhibition at St. Petersburg was formally opened on Saturday by the Russian Minister of Finance.

Station Burnt.—The central station at Ferdinand-street, Boston, U.S. was burnt to the ground last Saturday, and one man lost his life in the ruins.

Municipal Lighting.—One of the Paris municipal councillors, it is stated, is preparing a work on the electric lighting of towns, with full and interesting figures.

Santa Fe.—The electric light, it is stated, in Santa Fé has proved a failure, and the municipality has returned to kerosene. There must be reasons for this, and it would be well to know these.

National Telephones.—On Wednesday the Examiners on Standing Orders passed the National Telephone Company and New Telephone Company's Bills for obtaining further telephone facilities.

Old Students' Dance.—A Cinderella dance will be held by the Old Students' Association on Friday, February 19, at the Westminster Town Hall. Tickets, 3s. 6d. each, of the Hon. Sec., 28, Lanhill-road, Elgin-avenue, W.

Anglo-French Telephone.—The French Chamber has adopted the convention concluded with Great Britain defining the conditions, working, and use of the telephone communications between the two countries.

Yacht Lighting. — The yacht "Tycho Brahe," belonging to Mr. "Bonne-Chance" Wells—the gentleman who broke the bank at Monte Carlo—has been luxuriously lighted with electric light by Messrs. Laing, Wharton, and Down.

Portsmouth.—At the meeting of the Portsmouth Town Council last week the question of the report from the Electric Lighting Committee was brought forward by the Mayor, but was adjourned until the next monthly meeting.

Electric Exhibition at Moscow.—An electric exhibition is to be held at Moscow, from April 14 to October 14, 1892. It will comprise 12 divisions of electric engineering. New inventions shown will not lose the right to be patented in Russia.

Tenders for Manchester.—As will be seen by their advertisements, the Manchester Gas Committee are now open to receive tenders for the supply of dynamos and for the supply and laying of culverts and electric light mains. These must be sent in by Feb. 23rd.

Brussels.—The result of the tenders for Brussels is not yet announced. The six firms tendering have been invited to furnish graphical diagrams of working. It is expected that a central station to light 10,000 lamps in winter and 5,000 in summer will be first erected.

Spain. — Three additional towns in Spain, states *Industries*, are endeavouring to obtain permission to erect central electric light stations. One is Linares, the lead-producing centre; the next is Baesa, a small town in Andalusia; and, lastly, Alcaniz, in Aragon.

Chicago Exhibition.—The estimates of the electric light to be used in the World's Fair at Chicago show that twice as many electric lights will be used as there are at present in the whole of Chicago. The plans call for 10 times the capacity of all the plant used in the Paris Exhibition.

Society of Arts.—In consequence of the illness of Prof. W. C. Unwin, F.R.S., the Howard lectures on "The Development and Transmission of Power from Central Stations," which he was announced to deliver on the 5th February and five following Friday evenings, has been postponed.

The Brush Company.—Mr. Garcke has resigned the position of managing director of the Brush Electrical Engineering Company, but he retains his seat at the board of directors. Mr. Raworth and Mr. Sellon have been appointed joint managers, and Mr. Geipel has been appointed superintending engineer of the company.

Tutbury.—A movement is on foot to provide Tutbury with the electric light. It appears that motive power exists at the mill occupied by Messrs. Staton, and with little outlay sufficient light could be obtained. A circular has been issued to the parishioners, and the reply to this will determine whether the new light will be adopted.

Mr. Tesla's Lecture.—An extraordinary general meeting of the Institution of Electrical Engineers is to be held, by kind permission of the managers, at the Royal Institution, Albemarle-street, on Wednesday, 3rd February, at 8 p.m., when Mr. Nikola Tesla will give his paper upon "Experiments with Alternate Currents of High Potential and High Frequency."

Electric Boats.—The General Electric Traction Company have recently taken the shipbuilding yard lately occupied by Des Vignes, and are now engaged in building the hulls of their electric launches, which are fitted with gearing at the works at Platt's Island. They have three boats now in hand—one of these, a 25ft. boat, is a second order from a private gentleman for use on the Thames.

The Sea Serpent at Last.—In the Machinery Department of the Electrical Exhibition at the Crystal Palace may be seen a fine specimen of the "Gymnotus electricus," or sea serpent. This animal having swallowed a portion of the shore end of the Atlantic cable of 1859, became transformed into a powerful electrical machine. In the process of grappling for the fault the body was brought to the surface, and will be the subject of some interesting experiments!

Secondary Batteries.—The work upon "Secondary Batteries: being a Description of the Modern Apparatus for the Storage of Electrical Energy," by Mr. J. T. Niblett, illustrated, is now published (Biggs and Co., 3s. 6d.). The work is not a theoretical disquisition on the action of secondary batteries, but rather a careful description of all the recent commercial developments of Planté's discovery, and one which it is hoped will be of great service to electrical engineers.

"Year-Book of Commerce."—We have received the third year's issue of the "Year-Book of Commerce," being a statistical volume of reference for business-men, compiled by Kenric B. Murray, of the London Chamber of Commerce, assisted by members of numerous statistical societies; published by Cassell's; price 5s. For those who have to do with foreign trade, the state of the labour market, agriculture, exports, and so forth, the book must prove one of great value.

Electric Power for the City.—The Streets Committee of the City Commissioners of Sewers reported on Tuesday relative to a communication from the Board of Trade asking for the Commission's opinion on the systems by means of which electrical energy was to be supplied under the City electric lighting orders. They stated that

they ascertained from Mr. W. H. Preece, F.R.S., that no objections could be raised to the proposed modes of distributing electrical energy.

Cantor Lectures.—Prof. Forbes will continue his Cantor lectures at the Society of Arts on Monday, February 1st, at 8 p.m., on "Developments of Electrical Distribution," dealing with high-pressure supply; old attempts; alternate currents; transformers; feeders; sub-stations; overhead and underground conductors; generation of electricity by power obtained from a distance, from electricity, gas, compressed air, and water under pressure; load factors; waste products.

Electricity in Agriculture. — Prof. Warner, of Amherst Agricultural College, Massachusetts, has been making a series of investigations upon the influence of electricity in agriculture. The results of the research will be published. Mr. W. W. Rawson, market gardener, of Arlington, whose experiments we have already mentioned, has found that the use of electric light has increased his profits from the growth and sale of lettuces, etc., by more than 25 per cent.—a practical enough effect.

Telephones in Hotels.—An indication of the extending use of the telephone for private use is shown in the fact that The Adelphi Hotel, Liverpool, has been fitted with a complete interior telephonic installation. Each room on the three principal floors of the building is fitted with a call-box and magnetic transmitter, by means of which visitors may communicate with each other or with the hotel staff at any moment. The work was carried out by Mr. G. A. Nusbaum, of 29, Ludgate-hill, E.C.

Electrical Engineering as a Profession.—The University of Sydney have recognised the claims of electrical engineering by adopting a proposal by Prof. Threlfall at the last meeting of the senate, "that the faculty cordially approves of Prof. Threlfall's proposal for the establishment of a curriculum in electrical engineering, and recommends that it be carried out by the senate, including the suggestion of a grant of £300 for the necessary apparatus." It was also decided that the curriculum should lead up to the degree of Bachelor of Engineering in Electrical Engineering.

Where the Profit Goes.—The London County Council have found that, in order to supervise efficiently the work of installing the electric light in the central offices, it has been found necessary to employ an assistant inspector (Mr. J. J. Thornton) at £2 a week. Inasmuch as the extra assistance has been necessitated by the contractor's request to be allowed to work until 11.30 p.m., they think it would be reasonable to charge half the cost to Messrs. Andrews, the contractors, and have accordingly authorised the employment of the assistant inspector on that understanding.

Telephone Service in Bulgaria.—The new telephone service between Sofia and Philippopolis, a distance of 100 miles, was inaugurated with considerable ceremony on the 24th inst. by Prince Ferdinand in person. All the arrangements, which had been organised with great care by M. Matheff, Director-General of Posts and Telegraphs, were most successfully carried out. Amongst the distinguished personages present were M. Stambuloff (the Premier), M. Grecoff (Minister for Foreign Affairs), several members of the diplomatic body, and a number of civil and military officials of high rank.

Technical Instruction at Darlington. — The Technical Instruction Committee appointed by the Darlington Town Council have, with the grants from the County Council for technical education, made a good beginning by arranging with Principal Garnett, of the College of Science, of Newcastle, for the course of 12 lectures on electrical engineering. The charge for the course is nominal. The first lecture was given at the Kendrew-street Board Schools, and was well attended, the new departure being regarded with great interest by the leaders of education in the town, who are represented on the committee.

City and North London Railway.—Amongst the private Bills which have passed the initiatory stage of the Standing Orders is that of the Great Northern and City Railway Company, which, by the creation of a new company with capital powers to the extent of £1,500,000 and £500,000 borrowing powers, proposes to construct a new line of electric railway from the Great Northern line near Finsbury Park to Finsbury-pavement, upon the same principle and by the assistance of the same engineer, Mr. Greathead, as that which has been adopted by the already existing line of the City and South London Railway.

London County Council Offices.—The installation about which some comment was recently made, that for the London County Council's offices, is now nearly ready, and will be open for inspection and use shortly. The contract was let, it will be remembered, to Messrs. J. D. F. Andrews and Co., of 41, Parliament-street, for £1,490, the highest tender being nearly double this. It must not be supposed, however, that this was due to the use of Mr. Andrews's concentric wire system, as it was specially specified to have the two-wire conductors in casing. There are nearly 400 incandescent lamps, including fittings, all separately specified.

Chicago Exhibition Committee.—The first meeting of the Electricity Committee was held on Tuesday afternoon, 26th inst. Present: W. H. Preece, F.R.S., in the chair; Sir Frederick Abel, K.C.B., D.C.L., F.R.S., Colonel R. T. Armstrong, C.B., R.E., R. E. B. Crompton, Prof. James Dewar, M.A., F.R.S., Major-General E. R. Festing, F.R.S., Prof. George Forbes, M.A., F.R.S., Prof. G. Carey Foster, F.R.S., Edward Graves, Prof. D. E. Hughes, F.R.S., Gisbert Kapp, J. C. Lamb, C.M.G., W. M. Mordey, J. Fletcher Moulton, M.A., Q.C., F.R.S., Prof. John Perry, D.Sc., F.R.S., Alexander Siemens, Prof. Silvanus P. Thompson, D.Sc., F.R.S., with Sir Henry T. Wood, secretary of the Royal Commission.

Liverpool.—At the weekly meeting of the Liverpool Watch Committee, on Monday, the application by the Liverpool Electric Supply Company, Limited, for the Corporation to consent to a provisional order whereby the power of compulsory purchase should be fixed at 42 years, and the charge for electricity be made 8d. per unit all round, was not granted, the feeling of the committee being that to do so would not be desirable from their point of view. The matter had been reported upon by the city engineer, and last week a memorial was presented to the committee signed by 448 commercial firms in the centre of the city, using 13,379 lamps, asking the Corporation to grant the request of the company.

Leeds.—At a meeting of the Property Committee of the Leeds Corporation held last week, the committee had before them various matters affecting the electric lighting of the Municipal Buildings and Town Hall. It was resolved to recommend the Council to put a fresh installation in the Free Library, and overhaul the existing installation in the rest of the building and the Town Hall. It was stated that the installation in the library was put in when the buildings were erected, and it was now found that the wires were too small to carry the current. All the other parts were in good order. Mr. Nichol, of the borough engineer's office, was appointed to superintend the work, subject to the confirmation of the Council. The cost is estimated at about £500.

Search-Lights for the French Army.—The first of a series of experiments for the purpose of testing the qualities of a new electric light for use in the French Army has been made on the exercise ground at Satory, and a satisfactory result has been obtained. The object of the lamp, which resembles the search-lights used in the navy, is to facilitate night attacks, by rendering the movements of the enemy perfectly visible while concealing those of the offensive side. If adopted, the new light will enable troops to fire at the enemy without furnishing their opponents with any indication to guide their return fire but the flash of the rifles. In order that the lamp may be transported easily from place to place, it is mounted on a light carriage with high wheels, which will enable it to be used on any kind of ground.

Battersea.—The Electric Lighting Committee of the Battersea Vestry reported at the last meeting that they had considered as to the application to the Board of Trade by the Putney and Hammersmith Electric Light and Power Supply Company for a provisional order, and had conferred with the representatives of the company. The committee recommended that the Board of Trade be informed that the subject of electric lighting of the whole of the parish is at the present moment under the careful consideration of a committee specially appointed by the Vestry for the purpose, and that the Board of Trade be asked to defer their final decision upon the application for a short time to enable the Vestry to receive and consider the committee's report upon the subject and to come to a conclusion thereon. The recommendations were adopted.

Primary Batteries.—Offices have been opened at 29, Lloyd's-row, Clerkenwell, by the Marson Battery Company for a new form of primary battery for domestic lighting. When they have had some installations running successfully for a few months we hope they will send us particulars, especially as to cost and trouble of maintenance, as given by the users. We notice that it is claimed—nay, guaranteed—that an output of 1,000 watt hours can be obtained at a cost of 8½d., and they defy any other battery to come near this. We should think so! They give 2¼ amperes for 17 hours on short circuit without attention: all that is needful is a "fresh charge of exhitant"—a new name, we suppose, for "secret solution." There are many other advantages claimed, all of which we hope are possible of demonstration—but we doubt it.

Electric Light Signalling.—Experiments are being carried out on board the Torpedo School ship "Defiance" at Devonport under the direction of the torpedo officers and officers of the Royal Engineers with arrangements for night signalling by means of electric lights placed at the masthead. The experiment has frequently been tried, but hitherto with only partial success, owing to the difficulty of rendering the flashes distinct from each other, the lamps continuing to exhibit a faint glow for some time after the electric current has been shut off. Owing to this disadvantage, signalling by electric lamps can at present only be carried out at the rate of less than 50 words per minute, which is not found to be sufficiently rapid. Incandescent lamps are used, and the connection is made and cut off from the deck. It has been suggested that greater rapidity could be assured by using two sets of lamps.

Electric Sidewalk.—At the World's Fair, Chicago, the electric sidewalk is now in operation. It consists of an endless elevated track, elliptical in shape, 900ft. long, on which two continuous tracks move, a portion at three miles an hour, and a further portion at six miles an hour, the latter being furnished with seats. A passenger can easily step off the stationary part to the slower track and again to the quicker moving track. It thus forms a continuous tramcar, on which the passenger can step off when desired. The system is patented, and this track has been put down to demonstrate the practicability of the system by a company of which Mr. Arnold P. Gilmour is president. It is thought to be a valuable system for moving large masses of people over moderate distances, and will be used for this purpose at the exhibition. It is driven by a 107-h.p. Thomson-Houston motor, and is practically noiseless in operation.

Tenders for Sydney and Melbourne.—Advices from these Australian cities state that both are acting simultaneously as regards electric lighting. It is decided to give time enough in asking for tenders to allow of some of the great European firms to send in tenders for the necessary work. It is almost needless to point out that the firm obtaining either Sydney or Melbourne, or both, or the firms obtaining these contracts will be put into a most favourable position with regard to Australian business. Strenuous efforts will therefore be made to get the contracts, and our large firms must not rest satisfied with mere compliance with the letter of the specification, but must strain every nerve to obtain the work and make it successful. Many of the firms to which we refer have agents in Australia, and ought to be well acquainted with every move of the authorities, hence there ought to be no delay when the time comes to take action.

Thomson Electric Welding.—The Electric Welding Company, who purchased the Thomson electric welding patents at a high figure, have taken offices at 6, Great George-street, where they have photographs of an immense variety of electric welding machines for all purposes, from watchchains up to sheet anchors. The managing director is Mr. M. F. Armstrong; the secretary is Mr. G. Ensor Mount; and the manager Mr. William Parker. Machines have been installed in several parts of the county, besides Birmingham and Newcastle, and specimens are shown, amongst other things, of axes, of which the steel cutting edge is welded to an iron body. Numerous specimens of cannon shell welded by this process were lately on view from the U.S. Navy department. Electrical engineers will await with interest the details of the company's work, which it is probably too early yet to comment upon. The field is large and it is to be hoped the success will be coincident.

Rival Lighting Companies in Holborn.—Mr. Claremont, of the Metropolitan Electric Supply Corporation, waited on the Holborn Board of Works at their meeting last week to ask them not to consent to the application of another company to supply Holborn with electric light. There was not sufficient demand in Holborn, he maintained, to warrant the establishment of another company in the district. His corporation had endeavoured in every way possible to give satisfaction, and had never had a complaint or a breakdown; and, besides, their price was cheaper by ½d. a unit than that of any other company in London. In reply to a member, Mr. Claremont said that the company's station was capable of supplying far more light than they had application for. Mr. Moss, on behalf of the County of London Electric Company, Limited, asked the Board to assent to the application of his company. The Vestries of Clerkenwell and St. Luke had already given, he added, their consent to the application to the Board of Trade. The Board decided to grant the application of the County of London Electric Company, Limited.

A Great Electric Railway Scheme.—A telegram from Dalziel's correspondent at St. Louis, Michagan, says that a company has been incorporated at Springfield, Illinois, for the purpose of constructing an electric railroad from St. Louis to Chicago. The company proposes to lay

a double-track road as straight as an arrow, upon which it [illegible] run electric cars, which will travel at the rate of 100 miles an hour, and thus compass the distance in two hours and a half instead of eight hours, as now. The power station will be at Clinton, Illinois, where the company will work a coal mine of its own, using electric drills and mining machinery. In time, it is added, the line is expected to become a boulevard of farmers' houses, standing on city lots, while behind them will stretch wheat fields. The houses will be lighted and heated by electricity, and reapers, mowers, and thrashers will be driven by electric power. Among the directors is Dr. Wellington Adams, termed the inventor of the first electric motor. Nearly the entire right of way has been secured, and within a few weeks the contracts will all be let out. The company will endeavour to have the line in operation in time for the World's Fair. Another telegram states that the capital is one million dollars, and that Edison's system is to be used.

London Electric Mains. — The London County Council have sanctioned the laying of mains by the London Electric Supply Company in Stamford-street, Waterloo Bridge-road, and Westminster Bridge-road, on condition that the works in Westminster Bridge-road when once commenced be carried on continuously by day and by night until completed; that the mains be laid under the footways, and be kept 9in. below the under side of the paving wherever it is found practicable to do so; that where the mains cross the carriageways they be kept at the same depth below the concrete or the road material as the case may be; that the positions of the street boxes, and the mode of construction of them, shall be submitted to and approved by the Council's chief engineer; that all pipes or openings from or into the boxes shall be of such shape as to remove all risk of injury to the covering of the cables; that all cables crossing the boxes shall be supported from below in the boxes; that all service lines or small cables shall be protected, where leaving the boxes, by an extra lead covering or by wooden stoppers, and shall also have a copper wire of sufficient size carried from the service to the main cable, in good connection with the lead or iron outer casing; and that the ends of all mains terminating elsewhere than in a box shall be securely protected by iron caps, in addition to any other covering.

Electric Traction at Liverpool.—In moving the report of the Liverpool Tramway Company, the chairman referred to mechanical haulage, which they were anxious to see introduced on the line. Compressed air was expensive, and cables necessitated breaking up the streets. "Electricity," he said, "has been tried, and it answers well as a haulage power, but commercially the price is far more than horses. We had an offer for electrical haulage at 7d. per mile, with an additional charge of £1,600 for each car with its electrical machinery attached. The 7d. per mile is much more relatively than the cost of horse haulage, exclusive of the capital outlay of £1,600 for each car, and as we have 234 cars the total outlay would amount to £374,400. The company who made this offer of 7d. a mile, after making a long trial on our streets, offered the Glasgow Corporation the same service at 3½d. per mile, or just one-half the price offered to us. In explanation of this enormous difference they urged the physical difficulties of Liverpool by reason of the hilly streets in comparison with Glasgow. The latter city is considered to have streets with very steep gradients, but that the difficulties of our streets are infinitely greater appears to be quite true, because we have a written statement to that effect from the eminent company who made the trial on our lines during the last two years."

Telegraphing Without Wires.—Among the recent American patents is an interesting one by Edison for transmitting signals electrically without the interposition of connecting wires. In his specification he states he has discovered that, if sufficient elevation be obtained to overcome the curvature of the earth's surface and to reduce to the minimum the earth's absorption, electric telegraphing or signalling between distant points can be carried on by induction without the use of wires connecting the distant points. This discovery is especially applicable to telegraphing across bodies of water, or for communicating between ships at sea or between ships at sea and points on land, it being necessary, however, on land to increase the elevation, and the use of stationary balloons is mentioned. At sea, from an elevation of 100ft., communication can be made to a great distance, and the masts of the vessel, fitted with suitable metal plates, are suitable Connection is made to earth, and the high-resistance secondary circuit of an induction coil is placed in circuit between the condensing surface and the ground. The primary circuit includes a battery and a device for making the signals. Completion of the circuit produces impulses in the secondary, producing electrostatic impulses at the condenser; these are transmitted inductively through the air, and are made audible by the electromotograph in the distant condenser. By repeating the signals from ship to ship communication is to be established over the largest seas, or even oceans, while collisions between ships in fogs would be prevented. It is a very pretty idea worked out from his previous experiments in the induction telegraph, and we hope it may prove successful in practice.

Llangollen.—An installation has been just completed by Mr. William Sillery, of Wrexham, for R. Graisser, Esq., of Argoed Hall, near Llangollen, the proprietor of the Ruabon Chemical Works. The generating plant is placed at the chemical works, and consists of a Crompton dynamo, 110 volts, and a set of 60 accumulators used for lighting the works; arc lamps are also used. During the day the dynamo is run to charge 40 accumulators, 1½ miles away, at Mr. Graisser's residence. The accumulators used here throughout were patented by Mr. Sillery in April last year, manufactured by Messrs. Walker Parker, Limited, Chester. It is interesting to mention in connection with this installation that a third wire for telephone has been successfully erected upon the same poles as the electric leads communicating with the chief offices at Argoed Hall, near Llangollen. The leads cross the River Dee directly, and pass underneath the famous canal aqueduct built 100 years ago, then the wonder of the age. Mr. Sillery has also been directed by Mr. Graisser to devise a scheme to drive his works by electricity, obtaining the necessary power from the River Dee, where there is an abundant supply of water.—An installation has further just been completed at the mansion of E. S. Clark, Esq., proprietor of Llay Hall Colliery, driven from a Crompton dynamo, three-quarters of a mile distant, at the colliery, into 43 accumulators, E.P.S. type, 31-plate cells, and giving entire satisfaction. Mr. Sillery is also now placing the electric light down the pit, for which purpose four dynamos are being installed, with engine and house on surface to act as reserves for the Llay Hall Colliery, to which colliery he is electrical engineer. The cables and wires used throughout, also insulators, were supplied by the Telegraph Manufacturing Company, Helsby, near Warrington.

Schanschieff Batteries.—We were shown the draft prospectus of a new company the other day, with the imposing title of the Central Electric Company, with some well-known names as directors; capital £50,000. Thinking it was possibly a new railway or electric light company, we

looked at it with interest, and with some surprise saw—Schanschieff battery again. Now we have no wish whatever to prevent the Schanschieff battery being put on the market. It is a good and useful battery, if the price is not considered. It might possibly be of use to some instrument maker to take up this battery and make a special department for its supply for philosophical or lecture purposes, and so forth. But a company for £50,000 can only attempt work on false pretensions. It may be worth while to mention a few facts with reference to previous attempts and their results. The Schanschieff battery was the object of reports by high authorities, who accepted the statement of cost of material from the inventor. A syndicate was formed, and afterwards an enormous company, with a quarter of a million capital, if we remember rightly. But facts as to cost leaking out, this company returned the money subscribed, and the whole thing fell through. It has apparently now got into other hands, and attempts made to revive the company. Do these persons know what the cost of a unit of electricity by the Schanschieff battery really amounts to? Is it 7s. 6d. a unit, and, if so, how can they expect to get the battery taken up on any scale to justify thousands being subscribed? Do they know whether the cost of Schanschieff liquid for a few hand lamps at the Greenwich Observatory last year came to something like £30, while the present cost of bichromate cells and accumulators only cost about one-tenth of this for liquid? Anyone who knows the facts could hardly dream of using batteries causing so much expense, and we have not yet heard that anything has been done to reduce the cost to within even barely practicable limits. The Central Electric had better use dynamos and send round charged cells. There might possibly be use and profit in that proceeding.

Board of Trade Laboratory.—Captain Cardew and Mr. Rennie have been working hard to get the Board of Trade testing laboratory into complete order, so that the legal units of electrical supply to be adopted by Government may be determined ready for adoption at the forthcoming parliamentary session. The aim in these new tests has not been at all to make new determinations of the units, but to so accurately measure correlatively the ampere, the volt, and the ohm, by certain resistances and balances, that real units for comparison can be placed in the Board of Trade laboratory, and these can be certified and acknowledged as the legal units for the sale of electrical energy in Great Britain. For one thing, delay has arisen because they have not yet obtained the definite form of current-measuring apparatus from the Cambridge Instrument Company. A specimen balance is now in the laboratory, but does not entirely embody the needed mechanical construction. Primarily, the units required are first a distinct length of metal to be known as the legal ohm. This will be obtained from makers exact to the nearest degree possible to that of the true ohm as now known, and three copies will also be kept for comparison. Then careful experiments with Clark's standard cells, and with the voltameter test, will determine the strength of current of a legal ampere, and this again combined with the resistance will give the legal volt. The peculiarity of the instruments will be that the magnetism of iron does not enter into the tests; the attraction and repulsion of the currents will be weighed or balanced by actual weights, and these weights, under stipulated conditions, will represent the legal units. The laboratory has now an alternator driven by a motor supplying four to 1,000 volts alternating current, a Brush machine, specially made, giving up to 2,000 volts continuous. A 10,000-volt Ferranti transformer has been recently added, and a 50,000-volt transformer will also shortly be in use. The only actual work of the laboratory at present has been in testing meters, of which may be mentioned Schallenberger's, the Thomson-Houston, Ferranti, Teague, Frager, Desruelles et Chauvin, and others. These are tested for the range of their capacity, for length of run, for standing idle, for alternations of temperature, and so forth. The laboratory cannot fail to be one of the most important factors in British electrical engineering. The electrical profession may well be thankful to the energy and patience of the gentlemen who have it in charge.

Laing, Wharton, and Down.—A paragraph has recently appeared that Messrs. Laing, Wharton, and Down have removed from Bond-street and taken offices at 38, Parliament-street, and again a statement appears that Messrs. Laing, Wharton, and Down have not left Bond-street, and continue their work there. To those who know the position these statements are perfectly clear, but as there are probably many who do not know, we will explain the matter a little. Messrs. Laing, Wharton, and Down—of whom the partners are now Mr. Wharton, Mr. Down, and Mr. Davies—are a private firm carrying on the business of electrical contractors, manufacturers, and artistic fitting suppliers at 82A, New Bond-street, and City offices at 17, Gracechurch-street. They are open to supply and contract for all house work, mansions, fittings, and the general work of a high-class electrical contracting firm Besides this, there is the Laing, Wharton, and Down Construction Syndicate, Limited—a perfectly distinct affair — a limited company with the capital of £100,000. This company has really no connection with the first, except that it is managed by the three members of the first-mentioned firm, though we believe Mr. Wharton is principally occupied in its management. The Construction Syndicate undertakes large financial and company work in electric lighting; it owns the Thomson-Houston patents, and is proprietor of the works at Waterford, Reading, and Weybridge, besides having sold the plant to, or helped to form, the companies at Exeter, Bath, Taunton, and Fareham, besides the City of London. A similar operation is being carried out at Reading. The directorate of the Construction Syndicate is a peculiarly strong and interesting one. The chairman is Colonel Martindale, C.B., R.E. (retired), who takes great interest in electric distribution problems, and is one of the directors of the City of London Company. Next, Mr. Percy Westmacott, who was one of the founders, with Lord Armstrong, of Armstrong, Mitchell, and Co., at one time managing director of that company, but now an ordinary director, his great wealth evidently allowing his previously busy life to be taken more easily. The third director is Mr. Wilson Crewdson, connected to the Crewdson, Waterhouse, Barclay, and other banking interests, an influential man to have on any board. The last is Dr. Merz, of Newcastle-on-Tyne, chemical manufacturer, one of the founders, with Mr. J. W. Swan, of the original Swan Company, and an accomplished chemist and engineer, with great organising powers and knowledge of business. The Laing, Wharton, and Down Construction Syndicate, though a private limited company, is, of course, public to the extent of publishing its accounts in the usual way, and has paid a 5 per cent. dividend for the last three years. They also have, besides the Thomson-Houston patents, the rights in the Elihu Thomson high-rate alternator, which will probably be shown at the Crystal Palace Exhibition, lighting lamps from a single wire; with new motors, the Van Depoele pulsating-current rock drill, electric cranes, pumps, and other novelties, which cannot fail to create great interest at the Exhibition.

THE DETERMINATION OF THE EFFICIENCY OF DYNAMOS.

BY GISBERT KAPP.

(Concluded from page 88.)

This experimental evidence, then, disposes of the question why the efficiency of a machine should not be determined in the manner above indicated. The answer is that if tested in this manner the efficiency comes out too high, and if we wish to determine the efficiency accurately we must either test two machines together, or, if only one machine is available, we must from a previous test know the rate at which the losses increase with the load.

Fig. 1 shows the arrangement for an efficiency test when all the three machines are coupled in series. B and C are the armatures of the machines to be tested, and A is that of the machine supplying the current. The fields of the three machines are separately excited by a machine, D, and are indicated by the coils F_a, F_b, F_c, F_d. Ampere-meters and voltmeters would be applied to the field circuits, F_b and F_c, to determine the exciting energy, but these instruments are not shown in the diagram in order to avoid useless complication. A rheostat, R, is inserted into the field of dynamo B so that it may be weakened, and the current passing through the machines B and C is read on an ampere-meter, *a*. A voltmeter, V, is also connected up, as shown, so that by switching it on to contact *b*, we get the brush voltage of B, and by switching it on to contact *c* we get the brush voltage of C.

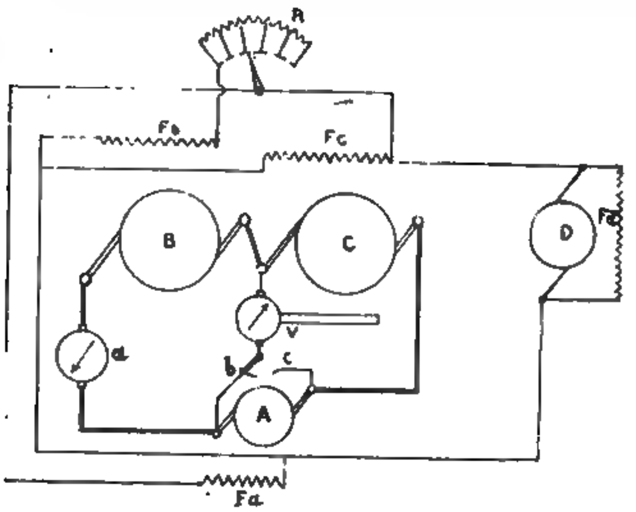


FIG. 1.

Since B and C are mechanically coupled they revolve at the same speed, and the voltage of B is therefore lower than that of C, the difference between the two readings being the voltage of the machine A, which supplies the power to keep the whole system going. The machine C works as a motor and B works as a generator. Calling e_c and e_b the respective brush volts, and C the current, we have the following relations:

Power supplied by A $= C(e_c - e_b)$
Power supplied to C $= C\,e_c$
Power obtained from B $= C\,e_b$

We neglect here the resistance of the connecting cables, since this can be made as small as desired. Now the ratio between the power obtained from B and that supplied to C is obviously the efficiency of the two armatures considered as one system, and since the current is the same (or can be made to be the same by taking the two volt readings in quick succession) we find that the efficiency is simply given by the ratio of the two voltages. The efficiency of each armature by itself is then given by the square root of this ratio, or

$$\eta = \sqrt{\frac{e_b}{e_c}}.$$

All we have therefore to do to get the efficiency is to adjust the rheostat, R, and the power supplied to dynamo A in such way as to obtain the normal current as indicated on the ampere-meter, *a*, and the normal speed of the machines B and C. Then by shifting the voltmeter contact several times between *b* and *c* we obtain with great accuracy the two voltages, and the square root of their ratio gives the efficiency. It is important to observe that neither the ampere-meter nor the voltmeter need be correctly calibrated. As far as the ampere-meter is concerned, all we have to do is to take care that it shall indicate the same current during the whole time that volt readings are taken, or that we reject those readings which happen to have been taken while the current was different. The voltmeter need not indicate true volts, but it must have the same percentage error within the range of readings required. Thus, if it is wrong by 5 per cent. at 100 volts, it must also be wrong by 5 per cent. at 90 volts and 110 volts. These limits suffice in practice, since with modern machines an armature efficiency of less than 90 per cent. need hardly be expected, and between such narrow limits even an ordinary commercial voltmeter may be relied upon to have nearly the same percentage error. A slight difference in the percentage error of the two readings will affect the result, but not to the full extent of this difference, since the efficiency is not the voltage ratio itself, but its square root. Say, for instance, that the indicated voltage ratio is ·88, but that there is a variation in the percentage error at the lower reading of 2¼ per cent. Then the true ratio would be ·86. The square root of ·88 is ·938, and that of ·86 is ·927. In estimating the efficiency we would then have an error of 1·1 per cent., although the voltmeter was wrong by 2·25 per cent. But even this error can be

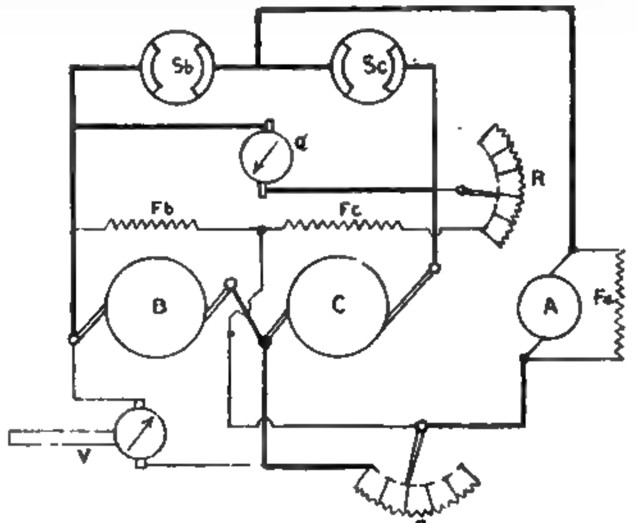


FIG. 2.

eliminated by making a second test, in which the rheostat is placed in the field circuit of C, so that B becomes the motor and C the generator, and then taking the mean between the two determinations.

It will be seen that the method here described is eminently suitable to give accurate results, even if our instruments are not absolutely reliable, but in practice there arise certain difficulties which sorely tax the skill and patience of the experimenter. The different adjustments which have to be made react on each other in a most bewildering way, and it is not always easy to see what should be done to get the system running under normal conditions. One difficulty the writer found was the tendency of the armatures B and C either to stop running altogether or else start off at racing pace. This difficulty was overcome by driving the dynamo A by an engine without a governor. In this way the engine itself took care to deliver a nearly constant current to the system, and the adjustment of the rheostat did not affect the current, but only the speed and voltage. Another difficulty is due to the fact that the total amount of power required to keep the system going is small in comparison with the work which may be stored in the revolving mass of the armatures, so that the effect of an adjustment at either the rheostat or any of the brushes is not immediately seen. The cure for this evil is, of course, to make all adjustments very gradually and not to hurry the test, but work patiently. Observing these and other precautions, which it would take too long to detail,

it is quite possible to make a very reliable efficiency test, but the plant required is rather elaborate. We must have two auxiliary dynamos and two steam engines, one without a governor, and giving exactly the torque corresponding to the current, and the machine driven by it must be of low voltage and large current, all of which requirements are not easily fulfilled.

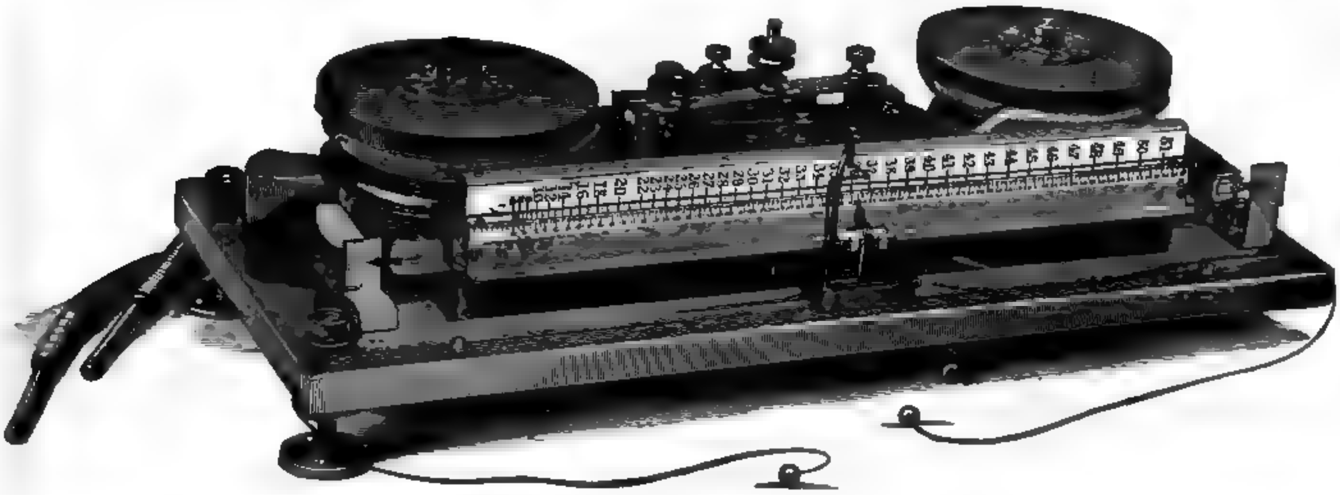
In these and other respects the method of parallel working is preferable. We require only one auxiliary dynamo of normal voltage, and giving a small current, and the engine may be of any convenient size, provided it is governed for constant speed. Fig. 2 shows the arrangement for this method of testing. B and C are again the two armatures mechanically coupled, F_b and F_c are their field coils, and in the latter is inserted the rheostat, R, by which the magnetisation of C may be sufficiently weakened to cause this machine to work as a motor. S_b and S_c are switches, which for the moment we suppose to be both closed. The voltage on both armatures is indicated on the voltmeter, V, and r is a rheostat chiefly used for starting, but also available if it be desired to work the machines to be tested at a lower voltage than that of the supply machine, A. This machine only gives the current required for excitation, and the difference between the current absorbed by C and given out by B. Suppose, now, everything to be properly adjusted, and the system to be at work. If we open switch S_c the auxiliary current will flow through switch S_b, and after being joined by the current coming from B will flow through the ampere-meter, a, and through the armature C. By opening the switch S_c, we therefore measure on the ampere-meter the current which C absorbs when working as motor. Similarly, if we close S_c and open S_b, we measure on the same ampere-meter the current which the generator B is delivering, and it is important to note that in both cases the current passes through the ampere-meter in the same direction, so that we need not fear the disturbing effect of residual magnetism, if any. If during the two readings the voltage remains the same, then the ratio of the two currents gives the efficiency of the two armatures considered as one system, and the square root of this ratio gives the efficiency of each armature, or

$$\eta = \sqrt{\frac{e_b}{e_c}}.$$

It is again obvious that the instrument need not indicate true amperes as long as the percentage error within the limits of the two readings is constant, and if we have a suspicion that the percentage error is not constant we need only put the rheostat into the field circuit of B and repeat the test, taking the mean of the two tests. One advantage of the method shown in Fig. 2 is that by it racing of the machines, or indeed any considerable variation of speed, becomes impossible, so that our adjustments are not liable to be disturbed by the inertia of the armatures. We need only adjust for current by shifting the contact on R until a little more than the normal current passes through C, and a little less than the normal current passes through B. If the steps on R give too coarse an adjustment, we can get the fine adjustment by moving the brushes on C.

THE CRYSTAL PALACE EXHIBITION.

One of the exhibits that will least attract attention from the thousands who go to see light and colour—who go with the intention perhaps of seeing how the light would suit their rooms—ought to receive the greatest possible attention from electrical engineers. We refer to Stand 151, of **Mr. J. White**, of Glasgow, who shows, amongst other things, a complete set of Sir W. Thomson's standard measuring instruments. While we agree that for practical use in central stations such instruments would be out of place, they are absolutely essential for all laboratory work. This stand was complete in time for the opening of the Exhibition. It is admitted by all who know aught of the subject that the greatest attention has been paid by Sir W. Thomson to electrical measurement. The outcome of this attention is the magnificent set of apparatus shown. In our issue of August 29, 1890, p. 173, and subsequent issues in the same volume, see pages 211, 237, 284, and 332, we illustrated and described most of these instruments. The value, however, of such instruments to the profession will be sufficient excuse for this further reference.



Sir William Thomson's Deka-Ampere Balance.

The standard direct-reading electric balances are founded on the mutual forces, discovered by Ampère, between movable and fixed portions of an electric circuit. The shape chosen for the mutually-influencing portions is circular, and each such part is called for brevity an ampere ring; or sometimes simply a ring, whether it consists of only one turn or of any number of turns of the conductor.

Cunynghame's Magnetic Cut-Out.

In each of the balance instruments, except the kilo-ampere balance, each movable ring is actuated by two fixed rings—all three approximately horizontal. There are two such groups of three rings—two movable rings attached to the two ends of a horizontal balance arm pulled, one of them up and the other down, by a pair of fixed rings in its

neighbourhood. The current is in opposite directions through the two movable rings to practically annul disturbance due to horizontal components of terrestrial or local magnetic forces. In the kilo-ampere balance the whole current passes through a single fixed ring and divides through two halves of a movable ring, which are urged one up and the other down by the resulting amperian force.

In all the instruments the balance arm is supported by two trunnions, each hung by an elastic ligament of fine wire, through which the current passes into and out of the circuit of the movable rings or ring.

In all the balance instruments, in which the movable ring is between two fixed rings, the mid-range position of each movable ring is in the horizontal plane nearly midway between the two fixed rings which act on it. The current goes in opposite directions through the two fixed rings, so that the movable ring is attracted by one of the fixed rings and repelled by the other. The position of the movable ring equi-distant from the two fixed rings is a position of minimum force, and the sighted position, for the sake of stability, is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the attracting ring by such an amount as to give about $\frac{2}{10}$ per cent. more than the minimum force.

In the balance instruments to measure alternate currents (which may be also used for direct currents) of from one ampere to 600 amperes the main current through each circle, whether of one turn or of more than one turn, is carried by a wire rope of which each component wire is insulated by silk covering, or otherwise, from its neighbour, in order to prevent the inductive action from altering the distribution of the current across the transverse section of the conductor.

The balancing is performed by means of a weight which slides on an approximately horizontal graduated arm attached to the balance; and there is a trough fixed on the right-hand end of the balance into which a proper counterpoise weight is placed, according to the particular one of the sliding weights in use at any time. For the fine adjustment of the zero a small metal flag is provided, as in an ordinary chemical balance. This flag is actuated by a fork, having a handle below the case outside, as shown in the illustration. To set the zero, the left-hand weight is placed with its pointer at the zero of the scale, and the flag is turned to one side or the other until it is found that, with no current going through the rings, the balance rests in its sighted position.

To measure a current, the weight is slipped along the scale until the balance rests in its sighted position. The strength of the current is then read off approximately on the fixed scale (called the inspectional scale), with aid of the finely-divided scale for more minute accuracy. Each number on the inspectional scale is twice the square root of the corresponding number on the fine scale of equal divisions.

Crompton's Projector—Stand No. 1.

The slipping of the weight into its proper position is performed by means of a self-releasing pendant, hanging from a hook carried by a sliding platform, which is pulled in the two directions by two silk threads passing through holes to the outside of the glass case.

Four pairs of weights (sliding and counterpoise), of which the sledge and its counterpoise constitute the first pair, are supplied with each instrument. These weights are adjusted in the ratios of 1 : 4 16 : 64, so that each pair gives a round number of amperes, or half-amperes, or quarter-amperes, or of decimal subdivisions or multiples of these magnitudes of current on the inspectional scale.

The useful range of each instrument is from 1 to 100 of the smallest current for which its sensibility suffices. The

ranges of the different types of this instrument regularly made are—

I.	Centi-ampere balance :	From	1 to 100 centi-amperes.
II.	Deci-ampere	" "	1 to 100 deci-amperes.
III.	Deka-ampere	" "	1 to 100 amperes
IV.	Hekto-ampere	" "	6 to 600 "
V.	Kilo-ampere	" "	25 to 2,500 "
VI.	Composite	" "	·02 to 500 "
			and from 100 to 25,000 watts (at 100 volts.

Besides the balances, the stand contains other instruments, which will be referred to later on.

becomes too great for the position at which it is set. In the old form alteration in the current at which the cut-out was to act could only be obtained by shifting the core of the solenoid, and as the ends dip into the mercury, this often deteriorates the contact considerably. In the improved form, embodied in Bryan's patent, the current passed round a pivoted solenoid, whose ends dip into mercury, the solenoid being drawn back on a curved core when the current exceeds a certain strength. The core is held by a set screw and made adjustable, and by altering its position the strength of current at which the cut-out is to act can be accurately determined. A number of these instruments, of various sizes, are shown

CAMEL WITH ELECTRIC LIGHT

CRYSTAL PALACE PANTOMIME 1892

The exhibit of **Messrs. Woodhouse and Rawson United** is very interesting from several points of view. One of Kingdon's alternating dynamos, as used at Woking, is the most important exhibit here, and will be a source of interest—the only other time it has been exhibited being at Frankfort. It is probable, however, that the attention of ordinary visitors will be most given to the flashing of incandescent lamps above the stand. The well-known diamond-shaped patterns, with the initials "W. & R."—their trade-mark—are formed in incandescent lamps, and will alternately be kept flashing on red and blue, after the method adopted with conspicuous success as a sign at the Trocadero, in Piccadilly. Switches in great variety are shown—single and double pole, quick-break. Amongst the cut-outs is a new and improved type of the Cunynghame magnetic cut-out, which we illustrate herewith. This cut-out acts, as is well known, by breaking a mercury contact when the magnetic effect of the current in the coil at the Crystal Palace Exhibition, having ranges of 1 to 40 amperes, 30 to 100 amperes, 100 to 250 amperes, 250 to 600 amperes, 600 to 1,000 amperes, thus forming a series of reliable current-breaking instruments.

Perhaps it was injudicious to take this sketch of **Messrs. Crompton's** Stand No. 1, but it will serve to show that they are exhibiting at least two projectors. We remember Mark Twain has a funny way of telling what certain marks in his sketches represent. It will be necessary to do this as regards the remarkable-looking things depicted as resting upon the table. They do not represent flat wires, but instruments of some kind. The fact is that when Mr. Bowles was making his sketch, this stand was hardly ready, whatever may be its condition now; and having on two separate occasions made up his mind to take the sketch, he would not be baulked at the second attempt. There is no mistaking the apparatus at the top of the wooden structure, which some-

one has called a "conning tower." It represents a conning tower about as much as a broomstick would, but there is no accounting for such mistakes. Manufacturers of electrical apparatus are always ready with a blessing for everything connected with projectors, for was it not the value of projectors in naval work that in the dull, dreary period of waiting for orders to instal light and power brought orders which kept the works agoing? The permission for ships carrying projectors to go through the Suez Canal by night brought orders from private firms; the use of projectors in warships brought orders from the Admiralty. The use of projectors, too, meant the use of dynamos, of engines, and, if we mistake not, had very much to do with the general adoption of electric light on board ship. At any rate, Messrs. Crompton, Messrs. Siemens, the Brush Company and others, have done a lot of work in this direction. The number of men who know the whole history of electrical development during the last 15 years is comparatively small. Few of the telegraphists troubled about the interloper about which so great a fuss was being made 15 years ago, and many of the prominent names of to-day are of those who entered the industry after the stir had been made. Mr. Crompton, however, was interested in the work from the beginning. Our recollection may not be verbally accurate, but we imagine it will be generally so. In the very early days of the electrical era Mr. Crompton was managing director of the Stanton Iron Works, and a partner in a small manufacturing business at Chelmsford principally connected with hot-water apparatus. Well, at one particular period some urgent work was required for the Stanton Company, and Mr. Crompton wanted men to continue the work night and day. But to work at night means light, and necessity led to the designing of his first arc lamps. They were successful, and were made in the small works at Chelmsford. Mr. Crompton soon saw there was money in electrical work, and, pitching cares to the winds, he went for it in a lump. He got it, too, as anyone will see who visits the Chelmsford and the Lillie Bridge Works of to-day and compares them with the old works of Dennis and Crompton. The Gramme patents controlled the make of one type of dynamo, the Siemens's patents controlled another type, but Mr. Crompton managed to get a type which interfered with none of these patents. He produced a thoroughly good knockabout machine. Of this we can speak with some degree of authority, as for the space of one or two years we had such a machine running under all conceivable conditions at our own house, and from first to last never had any trouble with it, yet as soon as the Gramme patents lapsed that type of armature superseded almost all others, and the Crompton-Burgin is now ancient history. As we say, Mr. Crompton's first experiments were in the direction of arc lighting, so that when the need for projectors was made clear, it is easily understood how he would give great attention to the matter. The outcome of this experience can be seen in the apparatus shown at the Palace. The projectors carry self-regulating arc lamps of 30,000 c.p.; and that their mechanical construction is excellent can be ascertained by examination.

Deane Brand as the Demon King—Crystal Palace Pantomime.

Kate Chard as the Fairy Queen—Crystal Palace Pantomime.

Each projector has a horizontal movement and a vertical movement. The horizontal movement can be all round the circle, but any one position can be retained by a clamping arrangement. Similarly, a large vertical range can be obtained. The lamp can be properly focussed by means of a screw; all the parts are simple—the gear strong and well made and of the best material. One of the projectors shown will be supplied with current from a battery of Crompton-Howell secondary batteries to be seen in the Machine Department. It seems almost a pity that some enterprising exhibitor did not think of putting a couple of projectors on the top of the Crystal Palace towers. It might have been a somewhat costly exhibit, but it certainly would have been an effective one. A novel departure at Stand No. 1 is that electrical measurements are to be taken, so that he who runs may read. It is to be hoped that one of those charming parrots at the end of the North Nave, or some equally eloquent speaker, will be pressed to explain simply to the audiences what is being done and why it is being done—but of this by-and-by.

It is not our province to discuss the merits or demerits of the **Crystal Palace Pantomime**. We have, however, to confess to a weakness for spectacular displays and tales from the Arabian Nights. We have usually found, too, that many of those who talk loudly about the degeneracy of pantomime manage soon after Boxing Night to familiarise themselves with the various pantomimes going. But the elder folk have no business to pass judgment upon this class of entertainment; it is sufficient if the younger generation are delighted. The first object of every caterer for public amusement is to make it pay, and whenever the amusement is of a healthy and innocent character it is the duty of the scribblers of the Press to assist in this end, for "All work and no play makes Jack a dull boy."

From year to year the Crystal Palace authorities produce a pantomime. This year Mr. Horace Lennard and Mr. Oscar Barrett have revived our old friend, "The Forty Thieves." As is usual, Mr. Barrett has called to his aid the most popular ditties of the day, and they most unmistakably give life and go to the performance. Of course the greatest attention has been paid to the spectacular part of the business, and gorgeous dresses, the sheen of polished metal, the flashing of colour from cut and tinted glass, with appropriate scenery, welds together an entertainment which for brightness, light, and colour has never been surpassed on these boards. We believe Mr. Barrett, jun., has painted the scenes. To this gentleman, too, we are indebted for many courtesies and much information. Electricity has been called in to play a moderate part in the spectacle. It was originally intended to use it to a much greater degree. Of the pantomime itself, we may sum it up in four lines from Calderon, as consisting of:

> In a word, delicious joys,
> Raptures, ravishments, entrancements,
> Pleasures, blisses, fondest favours,
> Sports and plays, and songs and dances.

These harmoniously intermingled, the eye and the ear enchanted, with the genuine flavour of clown and pantaloon thrown in, give some four hours of absorbing delight to the youngsters, and they view a scene

> Which comes . . . with songs and music,
> And a syren train to charm them.

But to our more prosaic task. How is the electric light used? Imagine the scene, which, of course, must include the beautiful Fairy Queen (Kate Chard), the Demon King (Deane Brand), and their attendants. In the "Forty Thieves" Cogia (S. Wilkinson) must be represented. Then we have the procession, and the ballet, and the transformation scene. The Fairy Queen, whose wand is more powerful for good than the demon's machinations are for evil, carries a brilliant lamp above her forehead, the current for which is obtained from a small secondary battery. Similarly the Demon King is provided with a lamp, while Cogia has three—one on the crown and two at the termination of long ringlets. In these cases the battery and connections are hidden within the folds of the dresses of the artistes. Two groups of attendants in the procession carry spears with decorative coloured streamers, and from just below the spear head appears a twinkling point of fire, as if the spear had a diamond setting. The effect is very good. The batteries supplying current to the spear head lights are carried in a small metal pocket on the spear shaft, hidden by the streamers. The secondary batteries have been supplied and

S. Wilkinson as Cogia—Crystal Palace Pantomime.

A Dainty Amazon—Crystal Palace Pantomime.

are maintained by the Mining and General Electric Lamp Company, whose stand we illustrated in our issue of Jan. 15th, p. 55. The current for charging the batteries is obtained from the Sydenham central station, just erected for the Electric Installation and Maintenance Company, by Messrs. J. E. H. Gordon and Co. In the transformation scene a number of camels are depicted, each carrying a lady, above whose head is a corona of incandescent lamps. These lamps are fed by means of flexible connections, easily connected to appropriate terminals in the stage floor and on the camels. The effect obtained is brilliant, and the audience see—

> Those who wear the rainbow's dress,
> Who within the car triumphal
> Above the busy throng are seated
> 'Neath a canopy, wherein
> Purple, pearl, and gold are blended.

Again the prosaic. The stage connections and fittings have been, we believe, done by Messrs. Rashleigh Phipps and Dawson, the current being from the ordinary Palace supply, by the Gulcher Company.

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CONTENTS.

CORRECTION.

Rotary-Current Plant.—*Owing to the inaccurate knowledge of our correspondent, the statements given in our note last week relating to the above apparatus in this country were incorrect. Mr. Henry Edmunds is the only representative of the Drehstrom interests here, and we regret the error of having connected the names of other gentlemen therewith.*

THE CRYSTAL PALACE EXHIBITION AND LOCAL AUTHORITIES.

It may be supposed that as this Exhibition approaches completion many of the exhibitors are thinking over the best way to make it pay. The various exhibits are of diverse character, and purchasers of one class of goods are only indirectly purchasers of another class. Thus, the wealthy owner of a country house may be directly interested both in generating plant, and in fittings, but the resident of a London mansion has little concern with the generating plant; his examination begins and ends with the fittings. Others there are who, passing by the fittings, care only for the generating plant. It must not be expected, however, that a great amount of business will be the direct outcome of the Exhibition: in most cases the ground will be merely laid for future approach and negotiation. It is well known that a number of local authorities have already made arrangements for the supply of electrical energy, either by erecting their own stations or backing up private companies. Many more authorities are considering the question, and it is absolutely certain most of the remainder will join the rolling ball of progress. The great manufacturing companies exhibiting at the Palace are more concerned with what the local authorities do and think than with any other class of visitor. Each, no doubt, would prefer to see all the local authorities one after the other coming to their private place of business or factory, and being there convinced that that firm or company was really the very best to carry out proposed work. That is a natural want—heads of firms and managers of companies may want, but cannot always obtain. The probability is that many of the local authorities will organise deputations to investigate the lighting apparatus at the Palace, and when no such deputation is sent to represent the authority, the engineer of the authority will be instructed to report thereon. If this should be the case, the exhibitors at the Palace ought to take care to be *well* represented. The ordinary stand representative is not what is required, but men of the world, men of business tact and ability, not eloquent scientific talkers. While the members of the deputations may not be conversant with matters electrical, and will certainly want to know more about interference with streets, Board of Trade requirements, obtaining of money, repayments of loans, mechanical construction and strength, they will, of course, require to know generally about dynamo, motor, and lamp efficiencies. They will also be interested to learn as much as possible about the "meters" proposed to be used to record the amount of electric energy consumed. There need be

no laboured explanation, but it would be advisable for the larger exhibitors to have meters at work, and be ready to explain their action. Depend upon it, there is instilled into men's minds a liking to return a compliment, and a clear explanation of apparatus to visitors will enable them to enlighten their colleagues and others upon points not usually well understood—will most likely bring them back to obtain further information when the progress of the work demands it. We have gone again and again to half-a-dozen exhibits to find no one at hand to explain anything, and no doubt visitors have done so likewise. The visit of formal deputations may usually be known beforehand, and it will no doubt be easy to arrange for these field days, but, at the same time, the unknown and the casual visitor ought not to be neglected.

THE PALL MALL COMPANY.

A long, but not altogether harmonious, meeting of this company was held on Tuesday last, and is fully reported in our present issue. The report is so full of pleasant, or unpleasant, surprises that it will prove interesting reading. There is, however, only one point to which we would now draw attention—founders' shares. This class of share is, in the majority of cases, merely a means to an end. The end is the delusion of shareholders. One of the directors of the Pall Mall Company failed to secure re-election at the meeting, and his co-directors demanded a poll, which takes place next week. The reason assigned for opposing such election was dabbling in founders' shares on the Stock Exchange, and a peculiarly rapid depreciation of the quotation for such securities. A dozen or so very pertinent questions were asked at the meeting, but in the end the report of the directors was adopted, so that whatever they may be thought to have done amiss is thus condoned. We suppose it must be granted that a man can sell his shares when and how he pleases, so that no reason exists for not selling founders' shares. We do not object to the selling—we object to their existence.

PROF. G. FORBES, F.R.S., ON DISTRIBUTION.

From year to year we have to acknowledge indebtedness to the Society of Arts for arranging at least one series of Cantor lectures upon electrical subjects. It will be remembered that last year Mr. G. Kapp gave an excellent series of lectures upon the transmission of power. The course of lectures commenced last Monday by Prof. G. Forbes, F.R.S., under the auspices of the society, is on electrical distribution—one of the most important subjects for the consideration of electrical engineers, and one to which Prof. Forbes has paid great attention. Eight years ago he gave a series of Cantor lectures upon the same subject, hence the comparisons he is able to make during the present course cannot but be valuable. It is well known that the society publishes these lectures in its *Journal*, and it has always been our custom to await this official publication before giving the lectures in our columns, because the lecturers, as a rule, merely indicate certain portions of their subject, giving the complete figures, details, and illustrations in the printed text. Of necessity, the first lecture in the present course was general rather than particular. The lecturer called attention to his work of eight years ago, and pointed out that then the tendency of practical men was wholly in favour of direct low-pressure systems. Since then, however, great advances have been made in alternate-current high-pressure systems, and, above all, in that useful accessory to central station work—the secondary battery. Eight years ago distribution rested with direct, multiple, and multiple series work. Now we have developed the three-wire and even the *n*-wire system. Prof. Forbes described at considerable length the system of distribution which required multi-feeding points, and gave some statistics as to the proportion between weight of feeders and weight of distributors in special installations, also the cost per yard run of several typical installations—such as the Kensington and Knightsbridge, the Berlin, and Clichy secteur in Paris. One point brought out by the lecturer during the course of the evening appeals to financiers. Many hundreds of tons of copper are used in mains, and it is by no means difficult to obtain advances of money upon the security of this copper.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

MAINS IN BATH.

SIR,—My attention has been called to a notice in your paper in which it is stated that the interruption of the light to certain lamps in Bath was due to contraction and expansion in the joints of the main.

No such thing has ever happened. Certain lamps have been extinguished for a short time on two occasions lately, but in each case the fault has been caused by bad workmanship on the part of the Bath Company's men, who have recently carried out alterations to the lamps.

There has been no contraction or expansion on the mains at their joints or elsewhere, and the Bath Company have had no trouble whatever arising from them.

As I have been called in to repair the defective wiring in the lampposts, I can speak on this subject with absolute knowledge of the facts.—Yours, etc.,

T. O. CALLENDER, Manager.

Callender's Company, 101, Leadenhall-street, E.C.,
January 26th, 1892.

ELECTROLYTIC LAW OF LEAST ENERGY.

SIR,—In a paper by Mr. G. C. V. Holmes, page 92, on the "Modern Applications of Electricity to Metallurgy," I note this remark, that metal will be first deposited from the solution which "requires the least amount of energy. This law was first stated by Dr. Kiliani, of Munich, etc., in the year 1885. The subject-matter of this law is a very large one."

I am not unused to seeing ideas which I have spread broadcast attributed to others, but this, as the French say, is *un peu trop fort*. The law, "Dr. Kiliani's law," is of my own formulation, and may be seen referred to at times as "Sprague's law."

I cannot say at what time it was conceived in my mind,

nor does it much matter; but in vol. xx., p. 2, of that paper of world-wide circulation, the *English Mechanic*, in September, 1874, it was first published in these words: "Let us substitute for the idea of *secondary chemical* action, this new definition of the action at the electrodes which will embrace all the facts. *At the electrodes those ions are set free* which absorb, *in becoming free*, specific energy."

Under the head of "General Law of Electrolysis," that statement has appeared in two editions, each 2,000 copies, of my "Electricity; its Theory, Sources, and Applications," both published before the date of Dr. Kiliani's paper, and in both I point out the resemblance of this law to the effects of destructive distillation. I may add that my definition was published years before even Berthelot formulated his chemical law of "maximum work," and in my second edition I said: "It is evident that M. Berthelot's law of "maximum work" is the converse of the general law of electrolysis which I have formulated."—Yours, etc.,

JOHN T. SPRAGUE.

MEDICAL ELECTRICITY.

SIR,—My attention has been called to the note on this subject in your issue of the 22nd inst., in which you observe that Mr. H. Newman Lawrence is attempting to apply electricity scientifically to the relief of paralysis. May I be permitted to state that Mr. Grigg, the world-famed medical electrician of Eastbourne-terrace—who has been in practice for nearly 50 years—many years ago invented and patented an electromagnetic machine which gives a beautiful and steady current without any shocks. By its aid he has been able to cure not only paralysis, but also diabetes, Bright's disease, typhoid fever, and all the worst cases of disease which had baffled the skill of the most eminent medical men.

Mr. Herford, the coroner for Manchester, in his letter to you of 24th August, 1888, says: "I could say much of my well-known (almost perfect) cure from complete prostration by paralysis, and of cures similarly effected from varied ailments amongst my friends. You will, perhaps, permit me to mention, from my own knowledge, what seems almost a miraculous case of a gentleman suffering three or four years ago from chronic rheumatic gout, progressive paralysis, enervation, etc. He was entirely helpless—hands and fingers drawn out of shape, legs and feet powerless. His physicians said his case was utterly hopeless; but his friends applied to Mr. Grigg, by whom he was treated twice a day for nine months, and recovered perfect use of his limbs and powers. He was married soon after, and has now a son and heir."

Mr. Thomas Helsby, an eminent writer, who has a practical knowledge of, and has written on, the subject, observes that "Mr. Grigg's patented machines are the best yet invented for medical purposes, and that he is the only man living who knows the proper and scientific mode of application for the cure of all diseases."

Mr. Grigg ridicules the idea of attempting to apply electricity successfully to the relief of paralysis in the way indicated in your note, and says, according to his experience, that either drugs or stimulants in any shape or form retard (in place of facilitate) the cure of diseases.—Yours, etc.,

DAVID RODAN.

13, Upper Montague-street, W.,
Jan. 27, 1892.

STEAM ENGINE ECONOMY.

SIR,—In reply to Messrs. Parsons's letter in your last week's issue, we are sorry to think that the figures upon which Mr. Willans based his remarks and his diagrams in the discussion on Mr. Crompton's paper should have been thought to be in any sense record figures. So far from this being the case, they were obtained from an engine which had not run very many hours. The rings had not, therefore, had time to come up to a face, and the engine was certainly not in a state to give the best possible results. It was a triple engine made for non-condensing work also, as all our engines have been up to now, and the best results could not be obtained from it when working condensing; moreover, in plotting the diagrams illustrating Mr. Willans's remarks, an efficiency $\left(\frac{\text{E.H.P.}}{\text{I.H.P.}}\right)$ of 80 per cent. only was taken, as he stated at the time. This is less than we often reach with new engines, and is certainly less than is usually reached after a few weeks' work with direct-current dynamos, working under the conditions which are present in electric lighting stations in this country.

At the low loads it was assumed that there were no reducing losses, which, even with the best dynamos, is not, strictly speaking, the case. The mean admission pressure in the cylinder at the highest observation taken in the condensing trial curve was 132lb. We have not a note of the pressure in the steam-chest, but it would be probably some 5lb. or 6lb. higher. The figures were used for the purpose of illustrating Mr. Willans's straight-line diagram, and in order to show (as was stated in his remarks) the gain which could be obtained, especially at light loads, even in the case of the very best possible non-condensing engine, by the use of a condenser. They were not intended in the case of the condensing trials to show by any means the best result obtainable. An engine which is to be used both condensing and non-condensing is at best a compromise.

The steam used in the trials was not tested at the time, but it probably contained 1 per cent. of moisture at the high loads, and was almost certainly dry, or even slightly superheated, at the lightest loads on account of throttling. The steam was taken through a separator in the ordinary way, but our trial boiler gives steam with about 2 per cent. of moisture in it, and this is not entirely removed by the separator so far as we have been able to ascertain.

Prof. Ewing did not give in his report the source from which he obtained the figures quoted. The figure 18·6lb. has been several times almost exactly obtained by us, and we did not know, until he mentioned the matter to Mr. Willans, that he was quoting from the *Proceedings* of the Institution of Civil Engineers. We should not have named that figure as an exceptionally good one, as we expect to do better.

In conclusion, we must heartily congratulate Messrs. Parsons on the results that they have obtained; we should not have written to the papers at all if these results had not been compared with our own.

Although we are quite sure that neither Messrs. Parsons nor Prof. Ewing had the least intention of saying anything which was not perfectly fair to us, there are many people who might make use of their report in a different manner if we had not written as we did.

The method, we believe, adopted by Messrs. Parsons of varying the power of the engine by admitting steam intermittently is a most interesting one, and, so far as we know, it is the first time that it has been applied to a steam engine. Undoubtedly, this method of reducing the power should tend in the direction of economy.—Yours, etc.,

WILLANS AND ROBINSON, LIMITED,
(C. S. Essex, Secretary),

Thames Ditton, Jan. 26, 1892.

PARSONS STEAM TURBINE.

The following letter from Principal Garnett, of the Durham College of Science, Newcastle-upon-Tyne, dated 25th January, 1892, addressed to Prof. Ewing, F.R.S., of Cambridge, has been forwarded to us for publication:

"My dear Ewing,—My attention has been called to some questions which have been raised respecting the effect of retardation of currents phase upon the output of the steam turbine, which you tested in Newcastle a few weeks ago. To determine the magnitude of the error thus caused, two sets of experiments were made, the former by Mr. Parsons and Mr. Stoney, the latter by Mr. Stoney and myself. In these experiments the coils used by you were compared with the water in a section of the cooling pond. The 1,000-volt armature was used, and iron pipes were thrust into the cooling pond to serve as electrodes, so that in comparison with the 1,000 volts the E.M.F. due to electrolysis was quite negligible, as was also any change of phase which it could produce.

"In order to secure the same number of true watts as the output of the alternator, the valve which gives the intermittent steam admission was blocked open and the steam was throttled by hand. In the second set of experiments the steam pressure at the point of admission to the cylinder was kept constant at 62lb., and the resistance was so arranged as to keep the volts the same with the coils as with the water resistance. A variation of pressure of 1lb. corresponds to about 1½ units per hour in the output. The volts being the same, and the resistance of the armature practically negligible, it follows that the speed must have been the same, and the speed and steam pressure being the same, its steam consumption, and therefore the output, must have been the same, unless the steam had the intelligence to know what was going on in the external circuit and the perversity to modify its conduct for the purpose of leading us astray. The result of this test was that with the same speed and the same steam pressure the product of Siemens and Cardew gave 49·5 for the water and 52 for the iron, showing an error of 5 per cent. due to the lag in the iron.

"In the other set of experiments the volts were kept the same, but the steam pressure as well as the amperes were allowed to vary, two sets of observations being made upon the coils, one with a greater and the other with a less output than in the case of the water. Repeated observations of the relation between the steam pressure and the load have enabled the law of variation of the one with the other to be accurately known, and it was therefore easy to interpolate between the two observations with the coils and to determine the apparent watts which would have been registered with the coils at the pressure used in the water experiment. The result of this interpolation showed that the product of Siemens and Cardew was 4·7 per cent. greater than the true watts.

"I hope that before long it will be possible to make a test of the turbine at the full working pressure of 140lb., and with a boiler of sufficient capacity to give fairly dry steam at full load. It was scarcely fair to the turbine to remove its high-pressure rings.—Very sincerely yours,

"(Signed) WM. GARNETT.

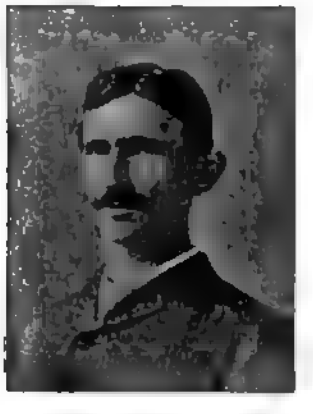
"To Prof. J. A. Ewing, M.A., F.R.S., etc."

MR. TESLA AND ROTARY CURRENTS.

Mr. Nikola Tesla is now in London, and electrical engineers will be pleased to learn is busy preparing his paper and his apparatus for the promised lecture to the Institution of Electrical Engineers upon alternating currents. This will appropriately take place at the Royal Institution, Albemarle-street, on Wednesday next, by the kind permission of the governors of the celebrated institution which the world-famous experiments of Faraday have rendered such classic ground to all scientific men. The occasion cannot but mark an important era in both theoretical and practical science, for the continuous attention, the experimental skill, and the keen insight of Mr. Tesla into the hitherto little explored ground of rapidly-alternating currents of high potential, with the astonishing results in demonstrating the possibility of lighting incandescent lamps without wires, have raised the expectations of scientific men to a high pitch. Mr. Tesla may well feel a little nervousness in coming before the scientific world in the capacity of apostle of a new and unexplored field, arising out of those opened up by Faraday's immortal experiments themselves; but the extreme beauty of the research, the importance, and apparently unlimited scope of the new experiments fitly carry forward the applications of electrical science whose basis was laid so thoroughly by Faraday in 1831.

For the moment, however, we will leave the fascinating question of high-potential electric illumination, and turn to that field in which Mr. Tesla has done, if possible, even more important work—that of the rotary current. The question of rotary current has taken a very different position in the eyes of English electrical engineers during the past year, due, to a very considerable extent, to the experiment on such a large scale at the recent Frankfort Exhibition, where the transmission of several hundred horse-power over a distance of 110 miles very forcibly brought the attention of the whole world to the importance of the rotary current. Before this time the knowledge upon the question was exceedingly vague, and, curiously enough, a long battle has raged around the very discovery of the rotary magnetic field and the rotary-current motor at a time when, in reality, there seems to have been not even a shadow of a doubt that the credit of the discovery and practical application of the system belonged to Mr. Tesla, who years ago had both patented and shown in working actual motors of the descriptions since shown in various other parts of the world.

The return of Mr. Tesla to Europe, together with the fuller details of his work, which will now be before us, will serve to create an entire revolution in the minds of a great many of those who are at present occupied, tentatively or practically, with this absorbingly interesting problem, and will put the whole question upon its proper basis. Until the publication in our columns a few months ago (September 11th, 1891, p. 246) of details and dates which were authoritatively given in America upon Mr. Tesla's experiments, the European electrical world was in doubt upon the whole question, or more probably gave the credit of the first discovery to Prof. Ferraris—whose work in this field certainly deserves the highest recognition—and the credit of the construction of the rotary-current motor, either singly or conjointly, to Herr Dobrowolsky, Herr Haselwander, or others.



NIKOLA TESLA.

It may be well to recall the dates given in the article above-mentioned. Prof. Ferraris's paper was given in March, 1888, and published shortly afterwards. Five months before this Mr. Tesla had filed his patents, and motors were run experimentally. On May 1, 1888, the patents were issued, and in the same month these motors were shown before the American Institute of Electrical Engineers, while it was not till May 18th that the work of Prof. Ferraris was published in England. As mentioned in our article on July 31st, 1891, it appears that Haselwander's rotary-current dynamo was constructed in the summer of 1889, and first set to work on 12th October of the same year; on July, 21, 1888, Haselwander applied for his German patents, which were accepted in 1890, and issued in June, 1890. Prof. Ferraris's experiments were undertaken in 1885, but Mr. Tesla claims to have been earlier afield. It seems, however, perfectly clear that men in widely separate localities were working independently, though contemporaneously, in the same direction and for similar objects.

On hearing that Mr. Tesla had arrived in London, we thought it well to take an early opportunity of calling upon him to obtain from him some particulars of the progress of the application of the rotary current in America, and to hear his views upon the question.

In the first place, it is interesting to learn that Mr. Tesla's discovery was due originally, not to direct experiment, but to abstract reasoning and mathematical calculation. A native of Montenegro, Mr. Tesla later came to Paris, and in the course of his lectures and study

was more particularly interested in the fascinating study of mathematical maxima and minima. Watching the action of the reversed dynamo running as a motor with segmented commutator, he suggested the desirability and the possibility of constructing a motor without commutator, which suggestion was scouted at the time. The march of his ideas, however, may be gauged from the mention of the maxima and minima theorem. Granted a rising and falling of E.M.F. in the commutator of a dynamo due to revolving position of the coils as now run, it was easy to jump to the conclusion that if waxing and waning currents could be sent into the coils in proper order, rotation should be at once obtained. Mr. Tesla is one of those gifted men who have that remarkable property, present in all men of high talent or genius, of an extraordinarily strong imaginative or conceptive faculty, by which material combinations are represented in the mind before they are constructed either on paper or in material substances. His motor was constructed and the results deliberately worked out in his mind before ever experiments were made; and he knew absolutely both that his motor would run, and which way it would run upon joining up the wires, and the result accrued exactly as expected. Unable to obtain sufficient

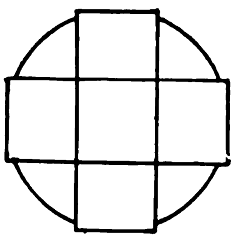


Fig. 1

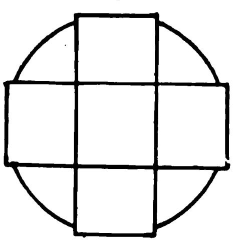


Fig 2

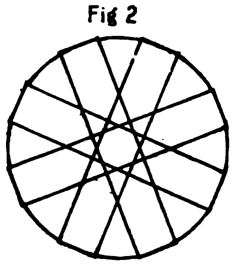


Fig 3

support in Europe, Mr. Tesla went to America, and there constructed and patented his motors. He constructed motors with the simple two-phase mentioned by Ferraris, in which the armature is wound at right angles, as indicated in Fig. 1. He constructed the three-phase motor since rendered famous as "Drehstrom" in Germany, in which the coils are distributed at an angle of 180deg. round the armature, as indicated in Fig. 2. He, further, long and exhaustively experimented with multiphase currents, both with split coils and with numerous separate currents, up to a dozen or more currents. The split multiphase current indicated in Fig. 3 is a simple modification of Fig. 2, by merely winding the three coils each in two coils disposed at a little distance from each other, thus producing a multiphase field; and he arrived conclusively at this result, that for practical purposes there is little to be gained in efficiency from the use of greatly-divided fields—not more, he finds, than of the nature of ½ per cent. gain. Motors were constructed, tested, and shown at the dates already mentioned, with efficiencies of over 90 per cent., and of great capacity for the weight—for instance, a 10-h.p. motor of 90 per cent. efficiency weighing only 850lb., half the weight of any of the same power since constructed in Europe. Results so promising, not to say revolutionary, could not but receive support, but his financial partners advised against publication of the full details and results, or European engineers would have long been in possession of the facts of the case. Mr Tesla's inventions, after being broadly protected in America, England, and Germany, amongst other countries, were taken up by Mr. Westinghouse, who proposed at once to put down large works capable of turning out 1,000 motors a week. Unfortunately, just at this moment occurred the financial panic which, it will be remembered, was suffered by the Westinghouse companies, and the matter had to be left. However, this has now been got over, and the motors are being made, and applied as fast as made. Mr. Tesla informs us—a fact that will astonish European electrical engineers considerably—that before he left he had seen running a 1,000 h.p. Tesla alternate-current motor, one of a number now being constructed at the Westinghouse Works in Pittsburgh for transmission of power. These are motors with revolving armature and three collector rings. Large numbers of the smaller motors have been in application for some time principally for mining purposes at high efficiencies and without needing repair. These motors start under load with strong torque: as an illustration, one experiment, with a small motor, was tried with a fixed rope over a 12in. pulley on the axle of the motor—the rope being previously tested to withstand 1,000lb. pull. On starting from rest the rope snapped immediately—a tangible demonstration of the strength of torque. Mr. Tesla states that his system of winding the alternate-current motors has now been brought to such a state of perfection, that for a three-wire circuit he can guarantee to build motors of large size to give 1 h.p. for every 20lb. of weight of an efficiency of 97½ per cent. What result better than this could be desired it is certainly difficult to imagine. It is evident, as we have said, that Mr. Tesla's appearance upon the scene will change the attitude of scientific men and engineers very considerably, both as regards the utilisation of rotary-current motors and as to the credit which should be given to this most interesting discovery.

INSTITUTION OF ELECTRICAL ENGINEERS.*

INAUGURAL ADDRESS OF PROF. W. E. AYRTON, F.R.S., PRESIDENT, ON ELECTROTECHNICS.

I beg to thank you for the great honour you have done me in electing me your president for this year—a year which the need for a new complete index of this Society's *Journal* marks out as closing the second decade of its life; a year which sees the second thousand added to our roll of members; and a year which the Electrical Exhibition at the Crystal Palace distinguishes as inaugurating the second decade of electric lighting in Great Britain.

It has gradually become the custom for your incoming president to select as the subject of his address some investigation that has been engaging his attention. Following this custom, I purpose to-night to discuss an experiment in which for the last 19 years I have taken some part—an experiment which of all others has been the one I have had most at heart—and that is, how best to train the young electrical engineer. To some it may appear that I am treading on well-worn ground; but as the problem is one that is as yet by no means solved, and as it involves the preparation of the machine that is daily used alike by the dynamo constructor, the cable manufacturer, the central station engineer, and the lamp maker—viz., the human machine—the problem of fashioning this tool, so that it may possess sharpness, an even temper, moral strength, and a mental grain capable of taking a high polish, is one that in truth deeply concerns every member, every associate, every student of this society. It is only 15 years ago since I wrote from Japan to my old and valued master Dr. Hirst, then the principal of the Royal Naval College, Greenwich, asking whether he thought that the time had come for starting in this country a course of applied physics somewhat on the lines of that given at the Imperial College of Engineering in Japan. He replied that England was not yet ripe for such an innovation—an opinion which appeared to be borne out by the fact that after the authorities at University College, London, had in 1878 actually advertised for applications for a new chair of "Technology," they decided that it would be premature to take the responsibility of creating such a professorship. But matters were advancing more rapidly than was imagined by collegiate bodies, for in that same year this most valuable report on technical education which I hold in my hand was issued by a committee of the Livery Companies of London, based on the opinions expressed by Sir W. (now Lord) Armstrong, Mr. G. C. T. Bartley, Colonel (now General) Donelly, Captain (now Sir Douglas) Galton, Prof. Huxley,

* Delivered on Thursday evening, January 28th.

and Mr. (now Sir H. Trueman) Wood. And although it is 12 years since this book was published, I can recommend it to your notice, for it supp ies most interesting reading even at the present day.

Under the guidance of the three joint honorary secretaries, Mr. John Watney, Mr. Sawyer, and Mr. (now Sir Owen) Roberts, the City and Guilds of London Institute for the Advancement of Technical Education started with a name that was very long, but in a way that was very modest, to develop a "trades school" in accordance with this report. They borrowed some rooms, but for use in the evening only, from the Middle-Class Schools in Cowper-street, Finsbury, and decided to erect ultimately a chemical laboratory in that neighbourhood. But neither the building of a physical nor even of a mechanical laboratory formed any part of the scheme for this "local trades school." For at that time the teaching of the practical applications of physics to industry hardly existed, and certainly not its application to any electrical industry other than telegraphy. To make a start, however, in such teaching was most desirable, and therefore Dr. Wormell, the enlightened head master of the Cowper-street Schools, consented to give up the use of some rooms not merely during the evening, but also during the day, to enable Dr. Armstrong and myself to carry out our plan of fitting up students' laboratories with a small amount of apparatus kept permanently ready in position. For the devotion of these rooms to the carrying out of this new experiment we must always feel grateful to Dr. Wormell, for it was necessarily accompanied by a reduction in the size of his school, and consequently by a pecuniary loss to himself. The first laboratory course of the City and Guilds Institute was then advertised, and on January 9, 1880, three students presented themselves—a little boy, a grey-haired lame man, and a middle-aged workman with emphatic but hazy notions about the electric fluid.

In order to further utilise these rooms the institute sanctioned laboratory teaching during the day, and one of the cellars of the Cowper-street Schools was borrowed in 1880 in order to fit up a gas engine, coned shafting, and a transmission dynamometer, obtained out of the funds of the institute; an A Gramme dynamo, lent by Mr. Sennett, then one of the students; and two arc-light dynamos for transmission of power experiments, lent by the Anglo-American Brush Corporation, whose cordial interest in the work of the City and Guilds Institute has been marked throughout. And as these dynamos were used, not for electric lighting, but as laboratory instruments for educational purposes, England can claim to have been one of the first in the field of teaching electro-technics. Rapidly grew these electro-technical classes; soon the temporary laboratories in Cowper-street were overcrowded, especially as applied mathematics and mechanics, under Prof. Perry, were added to the subjects taught; the £3,000 which had been set aside for the building of this "local trades school" grew into £35,000, thanks to the combined donations of the Drapers' Company and of the institute, and in 1881 was laid the foundation-stone of the present Finsbury College. During the many years that Prof. Perry and I were linked together, the work of either was the work of both; but now I wish to take this opportunity of acknowledging my personal debt of gratitude for the fund of suggestion which he put forth regarding the teaching of science through its practical applications—the keynote of true technical education. The value of these suggestions you will fully appreciate, for they form the basis of those characteristic and attractive lectures familiar to so many of you who have been his pupils.

As we have seen, then, the present Finsbury College grew out of the "local trades school," and formed no part of the original scheme of the institute. And it was because London was really in want of practical laboratory teaching about dynamos, motors, electric lamps, and engines, and because that want was supplied in a form suitable to the comprehension and to the pockets of workmen in the basement and cellars of the Cowper-street Schools, and last, but by no means least, because one of the executive committee of the institute, Mr. Robins, strenuously exerted himself to further technical education in Finsbury, that the various electrical, physical, and mechanical laboratories now in Leonard-street, Finsbury, came into existence. But the establishment of a central technical institution "for training technical teachers, and providing instruction for advanced students in applied art and science," had been recommended in all the reports sent in to the committee of the Livery Companies by the six authorities to whom I have referred. So that in the same year that the foundation-stone of the Finsbury College was laid by the late Duke of Albany that of the Central Technical Institution was laid by the Prince of Wales. And, if you will allow me to say so, the success of the latter institution has been no less marked than that of the former, for, in spite of the rather stiff entrance examination, the number of students who attend all four of the departments at the Central Institution is more than threefold what it was five years ago. In fact, in the mechanical and electrical engineering departments there are already about as many students under instruction as classroom and laboratory accommodation will admit. Hence this year will see a considerable increase in the amount of apparatus and machinery, as well as in the space devoted to dynamos and motors, in Exhibition-road.

While, on the one hand, the rapid growth of the work of the Guilds Institute is no little due to the fact that the latter end of this century has ushered in the electric age of the world; the electrical industry of our country, on the other hand, is no little indebted to the aid so generously given by our City companies to the teaching of electrotechnics. For the students who during the last 11 years have, for an almost nominal fee, worked in the electrical laboratories at Cowper-street, at the Finsbury College, and at the Central Institution, number several thousands, and nearly every electrical works, every place giving electro-technical instruction throughout this country, employs some of them. The success which these students have thus achieved through their own ability and exertions is, I think, in no small measure due to the institute having so wisely left the teaching it gave untrammelled by any outside examining body, so that it was possible for this teaching to be directed solely to the professional needs of the students, and to be modified from time to time as it seemed necessary. My hearty thanks are indeed due to the Japanese Government and the City and Guilds Institute, my masters during the last 19 years, for having left my colleagues and myself unfettered liberty to carry on this experiment of finding out better and better ways of teaching the applications of science to industry. And there need be no fear that with this freedom the teaching will become stereotyped, and gradually cease to deal with the living science of the factory, for being bound by no code we are able to vary our methods, our experiments, and our apparatus according to the continually-changing conditions of the profession. In order that the Guilds Institute should fulfil its aim, it is absolutely necessary that its teaching should keep pace with industrial progress. Now, even if it were possible for outside examiners, with fixed scholastic notions, to aid in securing this result, would not their efforts be superfluous, for are there not you, the employers of labour, to ultimately decide whether the human tool we fashion is, or is not, adapted to your requirements?

Leaving now the consideration of the direct work of the City and Guilds Institute, including their extended system of technological examinations, at which last year 7,322 candidates were examined in 53 different subjects at 245 different places in Great Britain and the Colonies, the indirect results that have proceeded from the initiative of this institute are even greater. For while 12 years ago education in applied science in this country was a tender little infant, requiring much watching and support, combined with constant encouragement, to-day Technical Education—with a capital T and a capital E, bear in mind—is a stalwart athlete, the strong man on the political platform, exercising the minds of county councillors, and actually regarded as of more importance than the vested interests of the publican. Until quite recently it was the technical education of the young engineer that had to be considered, but now the problem has become a far wider one, for the education of the British workman is being vigorously pushed forward, and I think that it has become incumbent on you—the representatives of the electrical profession—to express your decided opinion as to what this education of the electrical artisan ought to be. The technical education snowball set in motion 12 years ago by the City companies has been rolling—nay, bounding forward—so swiftly during the last year or two, that probably some of you have hardly followed it in its rapid growth both in size and speed. £30,000 has been spent on the Polytechnic in the Borough-road, the Charity Commissioners have already endowed this school with an income of £2,500 a year, and it is hoped that before the building is opened, this income will have been doubled. £50,000 has been already promised for the Battersea Polytechnic, the Charity Commissioners having also undertaken to provide this technical school with an income of £2,500 a year as soon as the subscription reaches £60,000; and for the establishment of a polytechnic in the City £50,000 has been set aside out of the funds of the Charity Commissioners, as well as a yearly grant of £5,350. Finally, not to speak of polytechnics in North, South, East, and West London, Mr. Quintin Hogg has himself spent £100,000 on the Regent-street Polytechnic; while the Drapers' Company have alone given £55,000 to the technical department of the People's Palace at Stepney, and endowed it with an income of £7,000 a year. And, most recently of all, the Goldsmiths' Company have put on one side nearly a quarter of a million sterling for the land, the buildings, and for an endowment of £5,000 a year in perpetuity, for their Technical and Recreative Institute recently opened at New Cross. The following table gives an idea of the sort of sums that are being spent on polytechnic education in London, but it does not profess to give the entire amounts that have been devoted to capital expenditure and yearly maintenance, even for the six polytechnics named in the table:

Capital Expenditure.		*Yearly Endowments.*	
POLYTECHNIC, BOROUGH-ROAD.			
Already spent........ ...	£30,000	Charity Commissioners alone	£2,500
		(Endowment expected to be doubled before opening.)	
BATTERSEA POLYTECHNIC.			
Already subscribed ...	£50,000	Charity Commissioners alone	£2,500
CITY POLYTECHNIC.			
Charity Commissioners alone to spend	£50,000	Charity Commissioners alone	£5,350
REGENT-STREET POLYTECHNIC.			
Spent by Mr. Quintin Hogg.....................	£100,000	Charity Commissioners alone	£3,500
Spent by Charity Commissioners	11,750		
PEOPLE'S PALACE, MILE END.			
Given by Drapers' Company alone	£55,000	Drapers' Company alone	£7,00
Given by Charity Commissioners alone	6,750	Charity Commissioners alone	3,500

TECHNICAL AND RECREATIVE INSTITUTE, NEW CROSS.

Given by Goldsmiths' Company	£70,000	Goldsmiths' Company..	£5,000
(Representing a total expenditure of nearly £250,000.)			
Other contributions to polytechnics in London by Charity Commissioners	£6,000	Yearly endowments of Charity Commissioners to other technical institutions in London	£3,200
TOTALS FROM THE ABOVE SOURCES ALONE :			
	£370,500		£32,500

Large as are these sums they are, however, even small compared with the amount raised by Mr. Goschen's beer and spirit tax, which it has been decided shall be used for the public benefit, and not for the benefit of the publican. The counties and county boroughs of England now receive nearly three-quarters of a million sterling per annum, of which the whole may be devoted to technical education. The majority of the counties and county boroughs propose to utilise this magnificent opportunity and devote to technical education the entire sum allocated to them, while the remainder use at least a part for this purpose. Middlesex and London, however, stand alone, and employ their whole yearly grant of £163,000 for the relief of the rates, on the plea that they consider that the City companies are well able to look after the technical education of London. Besides this spirit duty, 106 towns are levying rates in aid of technical education under the Technical Instruction Acts of 1889 and 1891, the number of these towns having increased by 20 in the last seven months, showing how rapidly is this desire for technical education spreading throughout Great Britain.

In addition to the sums contributed for technical education by the City companies, collegiate bodies, and private persons who have the practical education of the nation at heart, the following represent, as far as I have been able to ascertain, the amounts that it has been already decided shall be actually spent, yearly, on technical education in England alone, exclusive of Scotland, Ireland, and Wales:

Received from the Customs and Excise duties ...	£500,000
" " rates	18,046
Given by the Charity Commissioners	20,550
	£538,596

The yearly amount that will be actually raised under the Technical Instruction Acts will be far larger than the £18,046 stated above, for this represents only the sum of the amounts raised in the very few towns who have already made returns.

Hence the total sum to be spent in England alone on so-called technical education amounts to certainly over £600,000 per annum.

As the teaching of electrical technology has been started, in some form or other, in nearly every important town in Great Britain, there is no occasion for me to advocate, as I did in this room 10 years ago, that a student of electrical engineering should have an education in applied science; but what I desire to most strongly urge on you to-night is, that it is your bounden duty to see that some portion of the vast sum that is about to be spent on the education of the people is used to give such a training to your workmen as shall really benefit your industry. For otherwise there is a great fear that most of the money devoted to electrical teaching will either be frittered away on the natural loadstone, rubbed amber order of instruction so dear to the hearts of the schoolmen, or on semi-popular lectures describing in a bewildering, sketchy fashion the whole vast field of electrical engineering.

The workmen you employ are of two classes. In the one class is the man who is all day long, say, stamping out iron discs for armature cores, and the boy who, say, feeds the screw-making machine with its proper meals of brass rod. For such work no technical education is necessary; the workers are mere adjuncts to the machines, to be dispensed with as the machines become more and more perfect. Hence, unless the machine-minder has the ambition and the ability to rise to some less mechanical occupation, his activity, if any be left him after a hard day's work, had probably better be spent in effort of a lighter and more recreative character than would alone be necessary to make him a higher class of artisan. For him the polytechnic variety course of instruction is an inestimable blessing, for he can do a little typewriting, learn violin playing and modelling in clay, attend an ambulance class, recite a poem, and devote the remainder of his leisure to the piano botany, sanitary science, reading books and learning how to keep them. His general interests will be roused, the human side of his nature developed, and during the evening, at any rate, he may forget that he is the slave of the Gramme ring or the slave of the electric lamp. No wonder, then, that within two months of the opening of the Goldsmiths' Institute at New Cross 4,000 members were enrolled.

But your workmen of the other class must, or at any rate ought to, think. Take, for example, the man engaged in wiring houses, whose work is continually changing, and offering small problems to be solved. Here common sense, or uncommon sense, if you prefer it—is of great value, and the work, to be good, must be done by a man with a knowledge of principles, and not by a mere machine-minder. Many joints—bad joints—in wires laid in cement under mosaic, which cannot be replaced except at vast expense, even although the insulation has rotted away; parquetry floors nailed to insulated wire; switchboards screwed on to damp walls; lampholders that only make contact when the lamps are twisted askew; high-class insulated mains terminating in snake-like coils of flexible wire rubbing against metal in shop windows, under shop fronts; heavy Oriental metal lamps hanging from lightly-insulated cord; all this would be avoided, if the workman had been taught to use their brains as well as their hands.

Now, do you think that the teaching necessary for this purpose is likely to be given at the ordinary English polytechnic school? In the case of the Goldsmiths' Institute the electro-technical department has been put under the charge of Messrs. Dykes and Thornton, two diploma students of the Central Institution; and the fact that these men are, in addition, both employed in Messrs. Siemens's work at Charlton leads one to hope that their teaching, at any rate, will breathe the spirit of the factory. And, therefore, if ample funds be forthcoming for keeping the apparatus at New Cross always up to date, so that the motors, the models, the dynamos—not merely now at the start, but three years hence, six years hence—are truly representative of the industry, there will be a fair prospect that the electrical department of the Goldsmiths' Institute, although but a fraction of the whole undertaking, may really benefit the electrical workmen in the South-East of London. But my colleagues and I view with considerable apprehension the way in which the present wide demand for teachers in technical schools is being supplied. Several of our own students, for example, tempted by the comparatively high remuneration that is offered, have become teachers in technical schools immediately on leaving the Central Institution. In many respects they are undoubtedly well qualified; but if they had first spent some time in works before attempting to teach technical subjects they would have better understood the wants of the persons whom they have undertaken to instruct. No greater mistake can be made than to think that a student who has distinguished himself at a technical college can dispense with the training of the factory, unless it be the opposite mistake of imagining that the factory training is equivalent to, or even something better than that given at a modern school of engineering. It is the province of the manufacturer to turn out apparatus and machinery as cheaply, quickly, and as well made as is possible. It is the province of the technical teacher to prepare the human tool for subsequent grinding and polishing in the works. And this necessity for the teacher having himself passed through the shops has especial weight when we are dealing with the technical instruction of workmen, for in such a case there are three requirements absolutely necessary—first, knowing how to teach; second, possessing a fair knowledge of scientific principles; and thirdly—and this is perhaps the most important of all—knowing exactly what it is that the particular workman ought to learn in order to help him in his particular trade. Schoolmasters may have the first two requisites, and so may do valuable work in connection with the variety teaching at a polytechnic; but they are not in touch with the workshop, and therefore, no matter what may be their scholastic attainments, no matter what the extent of their experience in training the young, they are not the persons to give the real technical education to workmen.

In addition, then, to the polytechnics, we must have special schools for special industries, where workmen are taught the application of science to their special trades; and everything taught in such a school must be taught as bearing on the particular industry which the school is intended to benefit. A teacher of physics, for instance, must remember that he is not training physicists, but workmen whose use of physical principles will be bounded by their application to their special trade. For the great danger of such teachers is that, carried away with enthusiasm for their own subject, they will not subordinate it properly to the end in view—viz., helping the workman to know what will be useful to him in his work. Indeed, as Prof. Huxley pointed out in his original report to the Livery Companies' committee, "success in any form of practical life is not an affair of mere knowledge. Even in the learned professions, knowledge *per se* is of less consequence than people are apt to suppose. . . . A system of technical education may be so arranged as to help the scholar to use his intelligence, to acquire a fair store of elementary knowledge which shall be thorough as far as it goes, and to learn to employ his hands, while leaving him fresh, vigorous, and content; and such a system will render an invaluable service to all those who come under its influence. But if, on the other hand, education tends to the encouragement of bookishness, if it sets the goal of youthful ambition, not in knowing, but in being able to pass an examination, especially if it fosters the delusion that brain work is in itself a nobler or more respectable kind of occupation than handiwork, and leads to the sacrifice of health and strength in the pursuit of mere learning, then such a system may do incalculable harm, and lead to the rapid ruin of the industries it is intended to serve." And I venture to think that not merely at technical schools for workmen, but at technical colleges for engineers, it should be ever remembered that the main object of the training is not the cultivation of mental gymnastics, but to enable the student to acquire knowledge and habits which shall be professionally useful to him in after life.

"Useful learning usefully taught" would be no bad motto for technical institutions, seeing that those who favour the compulsory teaching of Greek are apparently willing to accept the converse as the motto for the university. For example, Mr. Butcher, in his address delivered at the end of last session at University College, Bangor, said, "We claim it as a distinction that in the seats of academic learning little or nothing useful is taught"; and in an article in last month's *Fortnightly Review*, congratulating Cambridge on its recent victory over the barbarian, Mr. Bury says, quite candidly, "Greek is useless, but its uselessness is the very strongest reason for its being a compulsory subject in the university course." And he add, in italics, "*For the true function of a university is the teaching of useless learning.*"

A few of the county councils have realised that the real teaching of the application of science to a special industry, which is what

the British workman is so much in need of, cannot be given, as well as a host of other subjects, out of limited funds. For example, Bedfordshire has decided to spend its grant of £4,343 mainly on agriculture, market gardening, the straw trade, domestic economy, and industries for women; Cambridgeshire and Cheshire devote themselves largely to the teaching of agricultural pursuits. But other places aim at issuing vast comprehensive programmes and turning out yearly a mighty array of students, knowing, it may be, the something of everything, but who certainly will not know the everything of something. For example, the Holland division of Lincolnshire has decided, out of only £2,000 a year, to make grants for daily schools, university extension and art schools, agricultural science, domestic economy, mechanics, commercial subjects, and ambulance teaching; while Bootle, with a yearly expenditure of only the same amount, maintains classes in five commercial subjects, in 16 science and art subjects, in cookery, wood-working tools, as well as four courses of university extension lectures. Because a certain building in Regent-street, famed for its ghost and its diving bell, was years ago named "The Polytechnic," the majority of the new technical institutions which are being established in London at such vast cost are also called "polytechnics," and will, I fear, give only an English polytechnic course. Now, such recreative education, although admirable for those who seek relief from work in the use of their minds, is not generally sufficient for those of your workmen who use their minds in their daily occupation.

It ought, then, to be thoroughly recognised that there is an entirely new problem to be solved, and that the solution of this problem, in so far as it has been worked out at the Finsbury College and at other places giving practical teaching in the evening, must, in the language of the mathematician, be regarded simply as "the singular solution," and not the general solution, of the problem of technically educating the British workman. Let us gratefully accept the English polytechnics, for they will undoubtedly confer benefit on our country, and all credit be to those who have so generously established them. But do not let us be misled by the similarity between their generic name and that of the German "polytechnicum" into fancying that the recreative courses of the one are equivalent to the serious education given by the other. Like Oliver Twist, let us ask for more, for, on behalf of the large number of minds already employed in the electrical industry, and on behalf of the still larger number that will in the future be so employed, it is our duty to secure that ample provision be made in this country for the practical teaching of electrotechnics on a scale comparable with that afforded in the technical high schools of Germany and the institutes of technology of the United States. On the screen you see projected a photograph of the façade of the Technical High School at Charlottenburg (Berlin), which appears extensive and grand; and yet, as you will see from the next photograph, it was only a small portion of the whole building that you were looking at on the first photograph. This is but one of the many technical high schools in different towns of Germany, and yet it covers an area more than five times as large as that occupied by the Central Technical Institution in Exhibition-road, London, cost four times as much to erect, and has more than four times as much spent on its yearly maintenance. The next photograph shows a building devoted wholly to the training of electrical engineers, being that of the Electro-Technical Institution Montefiore at Liège, which Prof. Gerard kindly took me over this last summer, and which has since been opened. When I tell you that there are rooms for small direct-current dynamos, separate rooms for large direct-current dynamos, separate rooms for alternators, and that every three students have a separate little laboratory, with the necessary measuring instruments, all to themselves, your educational mouth will water, as mine did.

We now cross the Atlantic to the Massachusetts Institute of Technology, Boston, which, as you see, consist of several distinct buildings, the centre one being that which contains the electrical laboratories. The dynamo-room, now seen on the screen, has many small and large dynamos in it, and yet there is ample room to walk about, for this dynamo-room occupies a space many times as large as that devoted to dynamos at the Central Technical Institution of London. Prof. Cross was so good as to mention in a letter that was shown me some two years ago, that several of the devices that had been worked out for the electrical laboratories of the City and Guilds Institute had been reproduced at Massachusetts; but there is one device that Prof. Cross has succeeded in working out, and which I should be most glad to see copied by the City and Guilds Institute, and that is, having one assistant for every five students working in the physical laboratories. Franklin Hall, presided over by Prof. Nichols, is devoted solely to the department of pure and applied physics at the Cornell University, Ithaca. You see how large this four-storeyed building must be, for look how small the four-wheeled waggon standing in front of it appears. The next three photographs show some of the provisions made for teaching electrotechnics in Franklin Hall; the electrical laboratory, under Prof. Moler; and the dynamo-room under Prof. Ryan, whose analysis of alternate-current curves are well known to you all. I might show you photographs of the electrical laboratories in Prof. Weber's new building for physics at Zurich, on which £100,000 has been already expended. In fact, my choice of magnificent continental and American laboratories has been so great that I have hardly known which to select as specimens. But there is one thing I cannot show you—and it must remain for the exercise of your influence as representatives of the electrical profession to make that possible—the British electro-technical laboratories for education and research which are truly worthy of London, the capital of the world.

The training of such students as those at the Central Institution must, of course, differ essentially from that of the electrical artisan, not because we or the students expect that on entering a factory at the conclusion of their college course they will start, as a rule, much above the bottom of the ladder, but because they hope in time to be able to mount higher. They are, therefore, taught not merely to construct meters and motors, use dynamos and engines, build a chimney and lay a street main, but, as they are not to spend all their lives wiring houses or watching a central station voltmeter, they are well practised in calculating and designing, and they further obtain sufficient acquaintance with the methods of attacking new problems not to be daunted when they meet with them in after life. But so strong is becoming our belief in the value of science to the manufacturer, so anti-classical are some of us growing, that there is great risk that the literary side of the education of an electrical engineer will soon be wholly neglected. Now, important as it no doubt is for him to be quite at home with electrical apparatus and machinery, it is no less important, if he is to take advantage quickly of the progress made abroad, that he should be able to read a German or a French newspaper. I do not merely mean that with a grammar and dictionary, and plenty of leisure, he should be able to translate the newspaper, sentence by sentence, like a schoolboy preparing to-morrow's lesson, but that he should have the power to glance down the columns, gather the gist of the articles, and quickly see whether there be anything new that especially concerns him. How many electricians are there in this country who can, for example, take up the *Zeitschrift für Instrumentenkunde* or the *Electrotechnische Zeitschrift* and look through their pages as they do those of the *Electrician*, the *Electrical Review*, and the *Electrical Engineer*, during breakfast on Friday morning. There are, I know, a few—I wish I were one of them. And yet examples are not wanting of the scientific isolation that is caused by not possessing that familiarity with foreign languages which is such a characteristic of diplomatists and hotel waiters. Take, for instance, the fact that whereas manganin was manufactured on a commercial scale in Germany, and German resistance coils have for the last three years been constructed of this material with a temperature coefficient of nearly zero, the very existence of this alloy was unknown to many English electrical instrument makers a few weeks ago; and even now many of them are still unacquainted with the composition of manganin, and its peculiar properties, as well as with the results of the extensive and striking experiments that have been carried out at the Reichsanstalt at Charlottenburg on the temperature coefficient and specific resistance of all sorts of manganin-copper-zinc-nickel-iron alloys. This Physikalisch-Technischen Reichsanstalt, I may mention, is an establishment totally distinct from the Technical High School in Charlottenburg, some photographs of which I showed you this evening. The Reichsanstalt is not an institution with students, but a vast series of Imperial laboratories, presided over by Prof. von Helmholtz, solely used for carrying out researches in pure and technical physics. The investigations are conducted under the direction of Dr. Loewenherz, aided by 46 assistants. We have no establishment in Great Britain at all comparable with this Reichsanstalt. The original work turned out there in electrotechnics alone is considerable. Here are some of the published accounts of researches immediately bearing on your profession which Dr. St. Lindeck has been so kind as to send me: "Hardening Steel Magnets," "Standard Resistance Coils for Large Currents," "Tests of Commercial Ammeters and Voltmeters," "Mercury Standard of Resistance," "Photometric Investigations," "Compensation Apparatus for Use in P.D. Measurements," "Alloys for Resistance Coils," and so on. Surely it is part of the technical education of the electrical engineer to be taught how to read such pamphlets as these with comparative ease.

A working knowledge of French and German can be obtained without the necessity of learning to express oneself fluently in epigrammatic French, or to imitate with facility the word-building of a native German; and with such a working knowledge the average technical student may rest content. But as regards his own language he should aim at something higher, and therefore the electrical engineering students of our country should be, I would urge, practised in writing—yes, and also speaking—vigorous English. Only the other day, Prof. Nichols, of the Cornell University, was deploring with me the rarity of finding a student of electrotechnics who could write a decent report. The experimental methods employed in the student's investigation might have been good, the mathematical analysis suitable, and the calculations exact; but the description of the apparatus and of the results obtained would be scattered pell-mell over the paper, as if the writer were quite ignorant of the fact that the style in which a dish is served up is nearly as important as the goodness of its ingredients. Why do you suppose that Huxley's portrait has nearly as much prominence given it in the photographer's window as that of a duke or a ballet dancer? Quite as much because he knows how to express himself in terse and forcible English as on account of his wide scientific knowledge; because even when writing about dry bones the flow of his language clothes them with rounded forms. But, you will ask, how are we to find the time for all this linguistic and literary polish? Has the electrical student of to-day so many spare hours that fresh subjects of study must be sought for to fill up his leisure moments? At present much time has to be wasted at technical and other colleges teaching students 16 years or older elementary mathematics and science, which ought to have been mastered before that age. When the education of childhood is improved, when the higher education of women is properly carried out, there will be no need for male experts to

trouble about general training, for then children will spend less time at school and learn more; boys and girls will as a matter of course acquire the foundation of modern languages and general education; and students at a college will be able to devote their whole time to the special training—scientific, manual, linguistic, and literary—which pertains to the particular profession which their special tastes will generally have led them to select before the age of 16.

And just as methods of teaching applied science have been developed during the past few years, so I look forward to the growth of new methods of teaching what may be called applied literature, for it seems to me that there is a want of breadth in the view that because the study of Greek verse would be unprofitable for a student of electrotechnics, and because he has neither the taste nor the time to enter into the intricacies of etymology and grammar, therefore the study of modern languages and literature, even as directly applicable to his profession, should form no part of his regular training. As well might it be thought (and I am sorry to say this view is not yet quite exploded) that because a student has neither the taste nor the time for the study of abstract mathematics, therefore he should be debarred from all work in a physical laboratory. Well, if it be generally accepted that although a young electrical engineer has no chance of becoming a Cayley or a Maxwell, still he ought to be taught such portions of mathematics and physics as will be directly useful to him in his profession, why should the certainty that he will neither become a Jebb nor a Dickens lead us to tolerate an inability on his part to speak fluently and write tersely his own language, surpassed only by his entire ignorance of every other? Habits of scientific thought are highly necessary for electrical students; to be masters of their own language, and to know something of one or two others, are, I venture to think, no less so; but the main result to be achieved, the main object to be aimed at, with every system of education, is moral thoroughness. For until every workman, foreman, engineer, and manufacturer feels regret and pain at seeing work inefficiently performed our national system of education will be incomplete. All the labour now expended in watching work in progress, and in testing it when completed to see that it has not been scamped, is so much withdrawn from the real business of production. Every rise, therefore, in the standard of thoroughness of a community means the saving of waste labour. But far greater than this will be the actual increase in the productive power when each gives his best endeavours to his share of the world's work. And greatest of all will be the gain in the nation's happiness, since he who works with his whole soul knows no drudgery. The lesson to be taught is no new one—it was set many centuries ago; and hundreds of thousands a year will be well spent if the county councils can succeed in bringing home to the hearts of us all this—"Whatsoever thy hand findeth to do, do it with thy might."

ELECTRO-HARMONIC SOCIETY.

A smoking concert will be held on Friday, February 5th, 1892, at the St. James's Hall Restaurant (Banquet-room), Regent-street, W., at eight o'clock.

Artistes: Mr. Schartau's Part Singers, Mr. H. Schartau, Mr. E. Dalzell, Mr W. Bradford, Mr. C. T. Johnson; clarinet, Mr L. Beddome; violin, Mr. T. E. Gatehouse; solo pianist, Mr. Alfred E. Izard. Musical directors: Mr. T. E. Gatehouse and Mr. Alfred Izard. A Broadwood piano will be used. The following is the programme:

PART I.

Plantation Chorus .... "Dinah Doe" ....
Mr. Schartau's Part Singers.

Clarinet Solo .... "Adelaida" .... Beethoven.
Mr. Leonard Beddome.

Song .... "By the Fountain" .... Adams.
Mr. E. Dalzell.

(a) Part Song .... "The Soldier's Farewell" .... MS.
(b) Humorous Quartette... "The Franklyn's Dogge" .... Dr. A. C. Mackenzie.
Mr. Schartau's Part Singers.

Pianoforte Solo ...... "Variations Sérieuses" Op. 57, Mendelssohn.
Mr. Alfred Izard.

Plantation Melody........ "Poor old Joe"...... Specially arranged.
Mr. Schartau's Part Singers.

Humorous Song...... "The General Election" .... MS.
Mr. H. Schartau.

PART II.

Vocal Polka .... "Trip, Trip" .... German.
Mr. Schartau's Part Singers.

Clarionet Solo ...... "Lo! here the gentle lark" .... Bishop.
Mr. L. Beddome.

Song...................... "The Diver" .... Loder.
Mr. W. Bradford.

(a) Part Song .... "Spin, spin" .... Jungst.
(b) Humorous Part Song "The Boy and the Tack." .... MS.
Mr. Schartau's Part Singers.

Violin Solo .... { (a) "Largo" } .... Handel.
{ (b) "Saltarella" } .... Papini.
Mr. T. E. Gatehouse.

Song .... "The Pilgrim of Love." .... Bishop.
Mr. E. Dalzell.

Part Song .... "When Evening's Twilight" ....Hatton.
Mr. Schartau's Part Singers.

CARDIFF AND ELECTRIC LIGHTING.

The Cardiff authorities have been collecting information as to electric lighting in other towns, and a report upon the subject was before the Council at its last meeting. It appears that over 50 towns have taken no steps whatever in the matter of lighting by electricity. Of the 16 boroughs whose replies are detailed, Accrington, Bradford, Brighton, Cambridge, Dover, Glasgow, Hastings, Huddersfield, Hull, Manchester, Richmond (Surrey), Walsall, and Worcester, have obtained provisional electric lighting orders, that of Brighton, though obtained in 1883, not being put in force till 1890. Neither Bognor, Eastbourne, nor Leamington has obtained such orders. Bognor is to be supplied by the Electric Trust Company, whose order provides for supply of public lamps by agreement, for a charge of 13s. 4d. per quarter for any amount up to 20 units, and 8d. per unit over that number. Eastbourne parades are lit by the Eastbourne Electric Lighting Company, whose arc and incandescent lamps are placed 100 yards apart, the charge both for public and private supply being 10d. per unit. The light, it is said, gives every satisfaction, but it is admitted to be costlier than gas. At Leamington a private, and not a public, supply is provided by a private company at a charge of 8d. per unit. At Bradford the scheme is not in operation as far as regards street lighting. The erection of works cost £5,213; mains, £3,361; machinery, etc., £24,354; and boilers and fittings, £3,174, making a total of £36,102. The sum borrowed totalled £34,342, the period allowed for repayment being 30 years. The light is also not used for street illumination at Brighton, where the cost is estimated at £35,000, in addition to £2,500 for land. The system adopted is that of low-tension continuous current, supplemented by storage batteries. The charge is 7d. per Board of Trade unit, the same charge being made for the supply for motive purposes. Cambridge has just applied for power to borrow £35,000; whilst at Dover the powers obtained by the Corporation are about to be transferred to the Brush Company. No works have yet been constructed, and no streets are yet lighted at Glasgow, but it has been decided to adopt the system of low-tension continuous current, and Prof. Kennedy, of London, has been engaged to prepare a scheme for putting down the installation for lighting the compulsory area. The Hastings Corporation has contracted with a local company for lighting 15 lamps on the parade at £30 per lamp per annum. The Huddersfield Corporation has entered into a contract for the erection of plant, and are applying for power to borrow £50,000. The Lighting Committee of the Hull Corporation are only about to take the initiative. They do not intend to light the streets at present, but only to supply private customers. The sum of £22,000 has been granted by the Council. The system is the low-pressure continuous current, and the price 7d. per unit. At Manchester a consulting engineer has been appointed, a site for a central station obtained, and plans and specifications are now being prepared. Richmond has entered into a contract with a company who have laid the wires. At Walsall a committee has reported in favour of carrying out the provisional order at once, at a total estimated cost of £21,450. The system has not yet been settled. The Worcester Corporation is also about to establish the necessary works to put their provisional order into force, and at the beginning of this month advertised for tenders for constructing works for the central portion of the city. These tenders are to be in by February 14.

COMPANIES' MEETINGS.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY.

The annual ordinary meeting of this Company was held at the St. James's Hall Restaurant, Piccadilly, W., on Tuesday afternoon, 26th inst., the chairman, Mr. Eustace J. A. Balfour, presiding.

The **Secretary**, Mr. F. J. Walker, having read the notice convening the meeting, and the Directors' report having been taken as read,

The **Chairman** said: The next business of the meeting is the proposal that the report and accounts for the year ending December 31st, 1891, as submitted by the Directors, be received and adopted, and that the dividends recommended therein be declared and paid on the 1st February.

This was seconded by **Mr. Latimer Clark.**

The **Chairman** then said: I don't think it is very necessary for me to go to any great detail into the working of the Company during the past year, because the report is very full, and I think on the whole gives such information as it is desirable should be placed in the hands of the public. Perhaps the most important event of the year was the raising of the £100,000 of additional capital in the form of preference shares for the completion of the northern station. The last £50,000 of this was largely oversubscribed at a premium of 30s., a fact which, I think, indicates that both the shareholders and the public in general show great confidence in the soundness of the business of the Company. This sum of £100,000 will, as you are aware, be chiefly, and has been partly, devoted to the purchase of the site for, and the erection of, our northern station. We expect this station when erected to be probably the best of its kind in the world, as it will

contain all the accumulated experience that we have gained in the erection of our present station, as well as that which other companies have gained in similar work. The machinery sufficient to furnish about 20,000 8-c.p. lamps is already nearly completed for that station, and will be placed in position as soon as the building is ready to receive it. It may be of interest to the shareholders to know that a large part of this machinery was running and supplying light at the Naval Exhibition, and that we have therefore this advantage in purchasing it—I may say it was purchased before it went there, and belonged to us while it was there—it has been running for this time without hitch or flaw, and we took it over, not as new experimental material, but as having been actually tried and found entirely satisfactory. A great feature in the system which we are now developing is what we call the great trunk main, which is already partially made, and which will connect the northern station with the existing station in Mason's-yard. It has a section of eight square inches, and is probably the largest main ever made. It is capable of carrying a current sufficient to supply 25,000 lamps. The importance of this cannot be over-estimated, because, well as our present station has worked up to the present time, and well as we expect it to work, it is impossible to suppose that it will not or may not be necessary to carry out repairs in it which may involve its being shut down for a short time. When this main has been constructed, and when the northern station is in working order, we shall be in a position during the slack months of the year to shut down either one station or the other for any repairs that may be desirable, and to work entirely from the one that is not shut down, and that without any alteration in the supply of the light in the consumers' houses. An eminent electrician connected with electric lighting told me some months ago that he thought that all new electric light stations should be built with two chimney shafts. Whether he is right or not in his opinion I do not venture to say, but the system that we propose to adopt combines all the conditions of his proposal and a number of others besides, in addition to being much more economical. I don't think I need add anything more on the particular subject of the working of the Company during the past year, but I should like before I sit down to touch upon a matter which I regard as of very great importance, not only to this Company but to all electric lighting companies, and to the whole question of the electric lighting of the Metropolis—I refer to the legislation under which we have obtained our provisional order. When legislation was first of all started with respect to electric lighting, in the year 1882, the term fixed for the expiry of a license was seven years. That is to say, licenses could be terminated by a local authority or the Board of Trade in seven years. This legislation seems to have been passed under a sort of morbid terror that electric light companies were going to become enormous corporations with great powers of monopoly. A provisional order under the same Act was limited to 21 years. The result of this extraordinary Act was that everybody who had invested their money in electric lighting concerns, lost it, and that the public was kept out of electric lighting for several years, London thereby becoming far behind any other capital in Europe in this matter, and far behind many towns and villages in the west of America. Under the present Act we have our provisional order lasting for 42 years, but that provisional order, and all provisional orders, are subject to two conditions: Firstly, that the Board of Trade can revise rates at the end of every seven years. That is to say, the Board of Trade can step in and say to us, "You are charging too much" at the end of every seven years of our tenure beginning from 1889; and secondly, that the Board of Trade has arranged to put into every parish, or district, or area in London at least two electric light companies. Now, if you will consider these points for a moment, I think you will see that they act first of all against the consumer indirectly, and also against the electric light companies. As we have only a terminable lease of life of 42 years, it is absolutely necessary for us to put by what we have termed a redemption fund, calculated to be sufficient to replace the deficit in the capital account, which we anticipate at the end of 42 years, when we shall or may be obliged to hand over our business at a valuation to the local authority, which has the option of purchasing. If our tenure were permanent, after paying to our shareholders a reasonable dividend, we could use the amount of this redemption fund in reducing the cost of the light. In the present year, I think, making a rough calculation, I may say that even if we paid to our present shareholders the same dividend as we propose to pay, we should have been able to reduce the cost of the light to the consumers about one penny out of every seven. Consequently, the power of septennial revision introduces an element of uncertainty into the business, which must be injurious to all the interests concerned. Nor is it likely that this revision can be made to work in a practical manner. Had the Board of Trade seen fit to grant complete monopolies in every district—that is, one company in every district—subject to some scheme of revision on a previously defined sliding scale, such a system might, I think, have been found to work. But as it is, on what basis are they going to revise? Supposing we have a case in one district, say a London parish, of two companies, one of which has paid on an average for the seven years a dividend of 20 per cent., and the other during the same period a dividend of 2 per cent. Is the Board of Trade going to insist upon the reduction of the cost of electric lighting because one company is paying and the other is not? In that case you might find the shareholders of the company that had paid a small dividend absolutely ruined. In fact, they (the Board of Trade) cannot get out of this, they will either be hard or unfair upon one of the companies, or upon the consumers in the district. In fact, I may say with respect to this, it is quite clear that the two systems which they have adopted of what they term limited competition and of revision of rates, are absolutely inconsistent. Now, lastly, the system of limited competition is injurious alike to consumer and producer, in that it makes it necessary to earn a dividend on a much larger capital than would be necessary to supply a district. Supposing you have two electric light stations and two sets of mains in one district, instead of one. The amount supplied in the district is the same, but the dividends have to be earned on a capital which, I think, I am not overstating to be at least half as much again as is required. You have, in addition to that, the disadvantage that the streets are pulled up twice for every time they ought to be, and you have also to consider that the initial expenses of a company have to be twice incurred, and these, gentlemen, are items which are very much larger than those who are not in the middle of the business are apt to think. I have no more to say, but I hope that if shareholders have any remarks to make or questions to put they will kindly do so.

Colonel Francis said he had some remarks to make as to the accounts, and some questions to ask, which he considered he was entitled to have answered in his own interest, and in that of large shareholders who had become interested in the Company on his recommendation. As to that paragraph of the report in which the net earnings of the Company during the past year were stated to be £10,395, he said that the net earnings of the Company for that period had been £15,409, and that part of the law charges item, £558, which included any expenses incurred in 1890, ought not to come out of the revenue of 1891. He had added to the net earnings, as stated in the paragraph, the total amount of the depreciation and redemption funds. His reason being as follows: He found that the very large sum of £1,702 had been charged during the year to the repair of machinery. When he was a director of the Company he consulted the makers of the machinery, and they informed him that if it were kept in perfect repair the depreciation was very slight. He (the speaker) held that a sum of 5 per cent. on the whole of the machinery would be ample for the purpose of depreciation. At all events he asked on what calculations the enormous sum of £4,013 (depreciation on buildings and machinery) had been worked out, if the sum of £1,702 had been spent on repairs? Had the original articles of association remained in force and not been altered, it would have been impossible to introduce such a charge as the redemption fund. They would see by referring to them that a reserve fund could only be applied for purposes indicated by a resolution of the Company in general meeting. This was article 76, old form, which had now been cut adrift. The painful impression of last year still remained, he believed, in the minds of shareholders. It was represented to them in the concluding paragraph of the report for 1890 that, in order to obtain a quotation on the Stock Exchange, it was necessary to remodel the articles of association. It was then discovered that the omission of the words "not to exceed £1,500" placed the shareholders at the mercy of the Directors. He wished to know the grounds on which the Directors said that there would be loss of capital at the expiration of the term covered by the provisional order. He had compared Section A, revenue account (cost of generation and distribution of electricity), for 1890 and 1891. The difference was more than double. He thought there would be no reason for surprise at this if there had been a large increase in the items of coal and labour. But he found that the enormous increase in this matter of expenses was otherwise carried out, the coal and labour charges only counting for £3,200. Turning to the capital account, he found that the sum of £20,297 had been paid for the new site of the northern station. They would remember that Mason's-yard cost £9,500, and that a site within 50 yards of the present one was obtained while he was a director of the Company for £1,100 and £100 a year, in Canton-street, which was nearly as large and as suitable. He had had the present site (northern station) valued by the most experienced surveyor of the parish, and he placed its value at £8,000. The offices of the St. James's Company were small in size, and, so far as he had observed, plain in appearance. There were three small rooms. However, the Directors had managed to spend £715 on furniture. Machinery and plant were spoken of as costing £12,000. Was that machinery in the new station or had it been supplied for the original one? Could not the capital accounts of the two stations be kept separate, so that shareholders might know exactly what each one was to cost? Now as to the financial arrangements of the Company; £100,000 had been obtained from shareholders for preference shares, paying interest at 7 per cent. At the time that this was proposed there was considerable opposition to it, for it was perfectly well known that the money could have been raised at 5 per cent. In fact, an offer of £50,000 at that rate had been made to the Directors and was spoken of at the last meeting. However, it was urged that if the sum was large, at any rate the original shareholders would benefit by the transaction. The original debenture holders who had power to convert did benefit, and in his opinion this transaction was executed for their benefit. Of this amount, it appeared that £27,000 were on deposit at Messrs. Lloyd's bank. He would like to know at what interest? The £15,000 premium that had been obtained by the issue of the second lot of shares was placed at 2½ per cent. He thought it was absolutely necessary in any case that the shareholders should obtain information of what was going on more than once a year. £353 had been spent for printing and advertising. He might be unfortunate, but he had never seen any advertisement of the Company's in any paper. Neither he nor any other shareholder had received any communication as to what had been going

on in the Company since the last meeting. They were in absolute ignorance, and remained in the Directors' hands. He did not think it ought to last. He would ask, upon what scale had the Directors gone in forming their estimates of depreciation on machinery and buildings? Had the whole of the sum of £558 become due for law charges in 1891? On what grounds did the Directors represent that there would be loss of capital at the expiration of the term covered by the general order? What course did the Directors intend to pursue in relation to their fees? Did they intend to replace the words "not to exceed £1,500" in the paragraph of the articles of association bearing on this matter? As printing was charged at the rate of £350 a year, would the Directors see that a full report of each meeting was sent to the shareholders? He thought those gentlemen who lived in the country and sent in proxies to the Directors, should have a fair and distinct report of that meeting. Would the Directors arrange that a meeting be held twice each year, in January and July? What amount was paid for the new site (of the northern station)? Who was the vendor? What surveyor acted on behalf of the Company, and recommended that sum to be paid? What sum was to be paid under the contract for building the new station? What sum would be spent on machinery? Could not the capital account of the two stations be kept separate? And then came the old question of the 18 founders' shares which were, as he firmly believed, most improperly and illegally handed over to the Debenture Corporation by its trustees? He had been to great expense about this matter, and had consulted counsel, who said all that he had got to do was to bring an action, and that no judge or jury could by any possibility sanction the proceeding. What did the Directors intend to do on that point?

Mr. Muirhead objected to their meeting in a public-house in the West-end instead of in the City, which would be much more convenient. He observed that it had deprived them of the attendance of two Directors (Mr. Kirby and Mr. Clarke). (It was explained that Mr. Kirby was detained in the Law Courts as a witness). He did not think the accounts were at all an exhibition of economy or management. He particularly pointed out the items for repairs and depreciation, and what he termed the "ridiculous" redemption fund. For this latter he could see no reason, because he presumed that Company was bound by Section 2 of the Electric Lighting Act of 1888. In that Act it was provided that should the property of the Company be taken over by the local authority the price to be paid was a fair market value at the time of purchase. He thought this value would be par at least. He observed that at compound interest the amount put by would rise beyond the requirements of the case—£95,000, he was understood to say. The law charges were preposterous. He thought the Chairman had taken an altogether pessimistic view, though he could quite understand that he did not want to make the best of the case, because the Board of Trade might be down on him. It was no use their knocking their heads against the Board of Trade; the Company were bound to conform with their requirements. It was to be regretted that they had the power to revise the Company's rates in seven years, but they would have to face that when it came. He didn't think the Board of Trade would be hoodwinked by accounts.

Mr. George Freeman thought their meetings ought to be held in the City, and that a verbatim report should be sent to the shareholders. He asked a question as to the interest on founders' shares, and the undivided profit account for founders' and ordinary shares.

Mr. Scrase wanted to know from the solicitor to whom the redemption fund would belong at the end of the concession—would it belong equally to founders and ordinary shares?

The **Chairman** said if there were no other questions he would go through those asked, as far as might be, *seriatim*. One or two of them, however, required a little reference to figures and the articles, so that he would have to consult his co-Directors as to the answers. First, on what scale was the estimate of depreciation formed? The matter was discussed with extreme care, and the scale adopted was the ordinary one in businesses of this character—viz., 1 per cent. on mains, 2½ per cent. on dynamos, general machinery, and plant; 10 per cent. on accumulators, etc.; 15 per cent. on boilers, and 25 per cent. on meters. Secondly, had the whole sum of £558 for law charges become due on the face of the accounts? This was not so. On what grounds did the Directors represent loss of capital? The Directors' ground was that it was notorious that it would be so, and they had taken it up under the best advice. They had discussed the matter for a very long time, and had come to that conclusion. Next, as to what course the Directors intended to pursue as to their fees? The answer to that question was given to Mr. Muirhead at the end of the last special meeting.

The **Solicitor** then answered Mr. Muirhead's objection to putting aside money in a redemption fund, because the 1888 Act provided for the purchase of the Company's business at a fair market value, arguing that it was the "then" value, and that the section should be read as a whole. **Mr. Muirhead**, however, reiterated his conviction that their property would be worth par at the end of the term, and might be at 100 per cent. premium. This discussion having terminated,

The **Chairman** said the next question was, did the Directors intend to replace the words in the articles, "not to exceed £1,500"? The Directors had no such intention. As to the printing charges, the Directors would consider the question of sending out a full report to shareholders. But, having regard to the fact that the printing expenses were high, they would hesitate to add to them. Would the Directors arrange for a meeting twice a year? They were quite prepared to consider that question. But, of course, having those meetings added enormously to the labour of the clerical staff and took up time. (A **Shareholder**: We pay for extra labour. Are we not to know what we are doing every half-year?) The Directors would consider the matter. The Chairman, returning to the list of questions, What was the amount paid for the new site? How long had the vendors held the property, and who was the surveyor? The amount paid was about £20,000. He did not know how long the vendors had held, but they were old holders, and there was a large number of them. The surveyor was Mr. Wilkinson, of 7, Poultry, E.C. The sum paid for the building contract was about £19,000. He could not say at that moment what sum had been spent on machinery, because they had not decided upon how much machinery was to be put in. That would depend upon the demand. As to the capital accounts of the two stations, the accounts were all kept in accordance with Board of Trade rules, and were audited by that Board. Answering the question, Why did they meet there (in the St. James's Restaurant)? the Chairman said it was because they were inside their own district, because the owner of the premises was a good customer, because it was close to the station, and because the Board thought it desirable to do so. The meeting, he remarked, was divided on the point whether they met there or in the City. If, however, the majority of shareholders would let the Board know that they preferred the meeting held elsewhere, they would meet them in the matter. As to what would happen at the end of the term of 42 years, supposing they were bought up by the local authority, to the surplus, if any, that accumulated, it would be divided in the proportion of 25 per cent. to the holders of vendors' shares, after paying back all capital to all shareholders. Having answered all the questions, with one exception, as he said, the Chairman put the resolution adopting the report and accounts, and declared it carried. So far as we could ascertain, there were 24 in favour and three against.

The **Chairman** next proposed the re-election of the retiring directors, Messrs. Egerton H. Clarke and H. Woodburn Kirby, but at the request of a shareholder, put the names separately. On his moving the re-election of Mr. Clarke,

Mr. Homan moved as an amendment that Mr. E. Clarke be not re-elected on the Board. Two of the Directors, he said, were not there (Mr. Clarke and Mr. Kirby), and they ought to have been. (The **Chairman** here interposed by reading a letter from Mr. Kirby stating his regret that he did not think he would be able to be present, as he was summoned as a witness at the Law Courts.) Whereupon **Mr. Homan** said he was perfectly satisfied with that explanation. Had the Chairman a similar letter from Mr. Egerton Clarke? (The **Chairman** said he had not.) Continuing, the speaker said that last Friday week, the 15th inst., being the day on which the Directors met to discuss the question of a dividend, Mr. Egerton Clarke actually sold on the Stock Exchange one founder's share, and having done so, came to the Board meeting to decide what the dividend on the founders' shares should be. Was that fair, equitable, or straightforward? That was not a speculative company, but one in which they considered they could put their money safely, and believed that when all differences of opinion were removed they would settle down into a steady dividend-paying concern. He thought, however, they had a right to expect that they had men on their Board who would not use the information they received as a means of jobbing in founders' or any other shares. Mr. Clarke sold the share at £355; the speaker was the buyer, so he knew something about it, though it was not bought for himself. Immediately afterwards the price went down to £270. He could not account for this, except that Mr. Clarke was about the Stock Exchange, he believed, as a buyer. He most strongly opposed Mr. Egerton Clarke's re-election to the Board.

This was seconded by **Mr. Muirhead** with the greatest possible pain and regret, because he would have liked to see Mr. Clarke present to answer or himself. At the same time there were certain facts concerning that Company which would not bear the light of day.

The **Chairman** said he was extremely sorry that question should have arisen, and was still more sorry that Mr. Clarke was not there to answer the allegations. He (the Chairman) had not the faintest notion that he was not coming. Of course he knew absolutely nothing of what went on on the Stock Exchange. He never went near it. But he could say that Mr. Clarke did not know what the resolution of the Board was going to be when he came into the room on that day (January 15). Was any notice given to him that it was intended to oppose his re-election?

Mr. Homan: No! Why should notice be given? His duty is to be here.

Mr. Davids asked whether the Board had at any previous meeting had any idea how the accounts were going to turn out.

The **Chairman** said the accounts were made up that very morning, and it was impossible for any Director to have a notion how they would turn out.

Mr. Davids: But the probable result had been discussed?

The **Chairman**: No. The auditor, who was there, would tell them when the accounts were made up. Not one of the points as to dividends, etc., were settled until the afternoon of the abovementioned day. (Several shareholders: Were they discussed?)

Mr. Homan said his point was that Mr. Clarke thought it advisable to sell his share. They had some reason to presume that he had a reason for selling it. Why did he do so? This ought to be explained by him in person.

Sir John Morris asked whether Mr. Clarke did not offer to buy back the share after selling it.

Mr. Homan said he could not tell.

The **Chairman** said he could safely say that the amount of the redemption fund was never discussed by any member of the Board before that afternoon, nor the amount of the dividend.

Colonel Francis asked who suggested the redemption fund if it was never discussed? He did not wish to imply that the Chairman was not stating what was not the case.

The **Chairman** said that he said the *amount* had not been discussed. As a matter of fact, the question of putting by that sum of money was discussed when he (Colonel Francis) was on the Board.

Colonel Francis stated that when he was a director it was said, What we will do is this: we must not give too large dividends to shareholders. We can give ourselves, as Directors, large fees—that, on my honour, is what occurred—it is easy enough to manage it.

The **Chairman** asked if Colonel Francis was speaking to any particular motion, to which the **Colonel** replied, "No; I am only answering questions."

The **Chairman** then put the amendment that Mr. Clarke be not re-elected a director, which was carried, there being apparently 20 in favour and three against it. He then, after a pause, stated that the Board thought it necessary to demand a poll. In answer to a Shareholder, who asked if the Directors were going to use their proxies in favour of Mr. Clarke, he said that the Directors would consider that point. Subsequently, he said they would not use their proxies for voting on this question. In order to give time to all parties to consider the matter, they had decided that the poll should take place that day week between the hours of three and half-past. (On the suggestion of a shareholder this was altered to between three and four), at the Company's offices. He hoped this would close the unpleasant incident for the time at any rate. He would be glad to appoint Mr. Homan scrutineer on one side, and the auditor on the other. This was agreed to.

The **Chairman** then proposed the re-election of Mr. Kirby as a director, which was seconded and carried unanimously, as also was the re-election of the auditors. This, he said, concluded the business of the meeting. There was one thing he would like to say, and that was that the thanks of the shareholders were due to their manager and secretary, Mr. Walker; their engineer, Mr. Dobson, and also to the staff for the energy and ability they had displayed. Night after night the staff had had to work up till 12 o'clock, because they could not get more people into the room at their disposal. Mr. Dobson, who had charge of the machinery and so on, had produced results which were shown by the report. He thought credit was often given to the Chairman and Directors when a large part of it ought to fall to the staff. This was carried by acclamation, and the proceedings terminated with a unanimous vote of thanks to the Chairman.

COMPANIES' REPORTS.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The report of the Directors, which is to be presented to the half-yearly meeting of the proprietors held to-day (Friday), states that the total receipts from the 1st July to the 31st December, 1891, including the balance of £527 brought forward from the last account, amounted to £164,121. This sum, however, is subject to revision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending before the Court of Appeal. The traffic receipts show an increase of £6,157 as compared with the corresponding period of last year, but this sum includes the adjustment of balances to 30th June last. The total expenses of the half-year, including repair of cables, etc., as shown by the revenue account, amount to £63,507. Interim dividends of 12s. 6d. per cent. on the ordinary stock, and £1 5s. per cent. on the preferred stock, were paid on the 31st October last, absorbing £43,750, leaving a balance of £56,864, out of which the Directors recommend the proprietors to declare final dividends of 16s. per cent. on the ordinary stock, and £1. 12s. per cent. on the preferred stock, amounting to £56,000, making a total distribution for the year ended the 31st December, 1891, of £2 12s. 6d. per cent. on the ordinary stock, and £5. 5s. per cent. on the preferred stock, leaving £864 to be carried forward to the next account. The Company's repairing steamship "Minia" has been engaged during the past half-year in the repair of the 1880 cable, the Brest-St. Pierre cable, the North and South Placentia cables, and the Duxbury cable. The "Minia" has also been employed in laying a cable from North Sydney, Cape Breton, to Canso, Nova Scotia, connecting this Company's system with the Western Union Company's cables between Canso and New York, thus providing an additional and alternative route, which, in the event of sudden pressure of business, or breakdown on the land lines, will be of great value. The new line completes through cable communication between England and New York City. The cost of the new cable has been charged to renewal fund. The Company's cables and land lines are in good working order, with the exception of the Brest-St. Pierre cable, which was again broken on the 18th November last, at about 275 miles from Brest. It is expected that the law-suit still pending between the Anglo Company and the Paris and New York Telegraph Company will be argued before the Appeal Court of Paris during the course of the coming month.

CITY AND SOUTH LONDON RAILWAY COMPANY.

Report of the Directors for the half-year ending December 31st, 1891, to be submitted to the fifteenth ordinary general meeting of the Company, to be held at Winchester House, on Tuesday next, February 2nd, at 12 o'clock.

Directors: Messrs. Charles Grey Mott (chairman), Harrow Weald Lodge, Stanmore; Charles Seymour Grenfell, Elibank, Taplow; Sampson Hanbury, Langford Park, Maldon, Essex; S. Barclay Heward, 57, Old Broad-street, London, E.C.; Edwin Tate, 21, Mincing-lane, London, E.C.

The receipts during the half-year from all sources amounted to £20,243. 15s. 4d. and the cost of working for that period to £15,516. 9s. 8d., leaving a net profit of £4,727. 5s. 8d. Including the amount brought forward from last half-year, the net revenue account shows a balance of £5,326. 0s. 9d.; of this amount the debenture interest absorbs £4,304. 10s., leaving a balance available for dividend of £1,021. 10s. 9d., out of which it is recommended that the full dividend of 5 per cent. be paid on the perpetual preference shares, and although the balance remaining would allow of a very small dividend on the ordinary shares, it is recommended that it be carried forward to the next account. The number of passengers carried by the railway in the past half-year was 2,749,055, showing an increase over the previous six months of 336,712, making the aggregate number carried since the opening of the line 5,349,580. Your Directors have, after mature consideration, found it necessary to vary the fares at certain stations between stated hours, with a result advantageous to the Company and to the comfort of the travelling public. To meet the convenience of residents along the line, a system of season tickets has been in operation since the 1st November last. Notwithstanding a considerable increase in the rates and taxes and other items over which your Directors have no control, they have satisfaction in reporting that the total expenditure shows a small decrease over that of the previous half-year, and it is hoped that some further reductions may still be made. The rolling-stock has recently been increased by the addition of the two new locomotives referred to in the last report, which it is hoped will give greater power and speed in working the trains, and the six additional carriages have also been delivered. The fourth engine and dynamo are now in course of erection for the generating station. During the past three months the traffic of the railway has shown a marked and satisfactory increase, which there is every reason to hope will continue and be still further augmented. To meet this growing traffic, arrangements are in progress for providing a more frequent train service during the busiest hours of the day. After the experience of the past year, there is every reason to be satisfied with the use of electricity as a motive power for the working of this railway, and for a confident belief that when all the details are fully perfected it will be found to be at once safe, convenient, and economical. The difficulties which have been experienced in dealing with the increasing traffic at the King William-street Station, owing to its confined dimensions and the steep incline leading to it, have induced your Directors to deposit a Bill by which they seek parliamentary powers to make a foot subway connecting the terminus of the London, Brighton, and South-Coast Railway Company at London Bridge with the station already authorised to be constructed at the corner of Denman-street, and also to construct two additional tunnels under the river with easy inclines to a central station at the corner of Lombard-street, and thence under Moorgate-street to The Angel at Islington, where ample siding room can be obtained at a small cost. These proposals meet with the approval of the Directors of the London, Brighton, and South Coast Railway, and will bring upon the line a very large and profitable traffic, and at the same time reduce considerably the cost of working the existing railway. It is also proposed to construct an inclined footway connection between this Company's station and the Monument Station of the Metropolitan and the Metropolitan District Railways, and powers for that purpose are included in the Bill. The Bill will be submitted for your approval at the conclusion of the half-yearly meeting. Owing to other engagements, Mr. Alexander Hubbard has resigned his seat at the Board, and the vacancy thus caused has been filled by the election of Mr. Edwin Tate, of 21, Mincing-lane, London. The director retiring is Mr. Charles Grey Mott, who is eligible for re-election. The auditors retire and are also eligible for re-election.

The statement of capital shows the total authorised capital to be £1,025,000—viz.: £800,000 in shares, and £225,000 in loans. £629,902 has been received in ordinary shares, leaving £20,000 unissued, and £9,216 in preference shares, leaving £140,380 unissued, the total share capital received being £639,118, and the amount unissued £160,380. An amount of £171,600 has been raised by loans, leaving available borrowing powers at December 31 last to the extent of £53,400. The total expenditure on capital account to December 31, 1891, was as follows: On lines open for traffic, £806,301; lines in course of construction, £7,942; and working stock, £34,100, a total of £848,344. Of this sum £825,828 was spent in the half-year ended June 30, 1891, and £22,516 in the half-year to December last. The total estimated expenditure on capital account during the ensuing half-year is £19,500, made up as follows: Lines open, £10,000; lines in course of construction, £5,000; rolling-stock, £4,500. Subsequent half-years are debited with an estimated capital expenditure on lines under construction of £145,000. To meet this further expenditure the accounts show capital powers and other available assets to the extent of £178,505. Maintenance of way and works, etc., during the half-year cost £491, of which £350 was for wages and £75 for materials. Locomotive and generating power cost £6,199, of which £100 was for salaries, £5,879 for running expenses (including £3,258 for wages and £1,985 for coal and coke), and £219 for repairs and renewals. Carriage repairs and renewals cost £365. Traffic expenses absorbed £6,369, of which £3,950 was for salaries, wages, etc., and £1,569 for hydraulics. General charges account for £1,592, of which

£650 went to Directors, £434 to salaries, and £272 to office expenses. We give below in detail the revenue account and the general balance-sheet.

REVENUE ACCOUNT FOR THE HALF-YEAR ENDING DEC. 31ST, 1891.

Dr.	£	s.	d.
Maintenance of way, works, and stations	491	4	7
Locomotive and generating power	6,199	12	11
Carriage and waggon repairs	365	0	10
Traffic expenses	6,369	8	0
General charges	1,522	3	6
Law charges	66	12	4
Compensation	91	18	6
Rates and taxes	410	9	0
	15,516	9	8
Balance carried to net revenue account	4,727	5	8
	£20,243	15	4

Cr.	£	s.	d.	£	s.	d.
Passengers—						
2,749,055	19,550	2	10			
323 season tickets	248	13	8			
Parcels, etc.	5	5	11			
				19,804	2	5
Transfer fees				3	17	6
Rent of property, etc., net				435	15	5
				£20,243	15	4

GENERAL BALANCE-SHEET.

Dr.	£	s.	d.
Balance from revenue account	1,021	10	9
Unpaid interest	154	1	10
Interest payable or accruing and provided for	2,116	5	11
Sundry outstanding accounts	34,893	15	7
Lloyd's bonds	8,000	0	0
Construction reserve	3,314	3	9
	£49,499	17	10

Cr.	£	s.	d.	£	s.	d.
Cash at bankers—current account	2,236	19	11	2,403	4	4
„ in hand	166	4	5			
General stores—stock of materials on hand				1,922	12	1
Sundry outstanding accounts				134	8	11
Islington extensions, parliamentary expenses paid				2,191	3	2
Parliamentary deposit, 1890 Act				7,071	13	0
Balance from capital account				35,776	16	4
				£49,499	17	10

PROVISIONAL PATENTS, 1892.

JANUARY 11.

548. **Improvements in holders for incandescent electric lamps.** Edwin Percival Allam, 8, Fountayne-road, Stoke Newington, London.

JANUARY 12.

568. **Improvements in electric incandescent lamps.** Godfrey Bamberg, 17, Weston-road, Southend-on-Sea.

576. **A new or improved automatic electric heat alarm.** Hugh Donald Fitzpatrick, 70, Wellington-street, Glasgow. (The Electric Heat Alarm Company, United States.) (Complete specification.)

638. **Improvements in telephonic switching appliances.** Parnell Rabbidge, 10, Southampton-buildings, London. (Complete specification.)

645. **Improvements relating to electric welding.** Peter Gendron, 45, Southampton-buildings, London. (Complete specification.)

JANUARY 13.

650. **Improvements in methods of operating alternating-current electro-motors, and in apparatus therefor.** Rankin Kennedy, Carntyne Electric Works, Shettleston, Glasgow.

JANUARY 14.

772. **Electric shade holder.** James Clerk Swanne, 53, Albyn-road, St. John's, London.

785. **Improvements in regulating sockets or fixtures for incandescent electric lamps and other translating devices, and in methods of regulating the flow of current to such lamps and other devices.** Elias Elkin Ries, 430, S. Broadway, Baltimore, Maryland, U.S.A. (Date applied for under Patents Act 1883, Section 103, July 6, 1891, being date of application in the United States). (Complete specification.)

791. **Improvements in laying and insulating electrical wires.** J. B. Hamond, 1, Quality-court, London.

798. **Improvements in electrical conductors.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, London. (Messrs. Siemens and Halske, Germany). (Complete specification.)

JANUARY 15.

825. **Improvements in electric cables.** Wallace Fairweather, 62, St. Vincent-street, Glasgow. (Eugene Francis Phillips, Unites States.) (Complete specification.)

831. **Improvements in fixed or movable electrical switch for incandescent lamps.** James Hunter, Leith, Scotland,

843. **Improvements in and connected with mounting incandescent lamps for safety purposes particularly applicable to electric miners' safety lamps.** Theophilus Coad, 1, Quality-court, Chancery-lane, London.

871. **Improvements in electric cables.** Henry Harris Lake, 45, Southampton-buildings, London. (David Brooks, jun., United States.)

873. **Improvements in electric lighting, and for other like purposes.** Robert James Rae, 79, Valentine-road, Walthamstow, Essex.

JANUARY 16.

925. **Improvements in telephonic receivers.** Alexander Marr, 70, Market-street, Manchester.

SPECIFICATIONS PUBLISHED.

1891.

1251. **Electrical switches.** E. and W. Atkins. 8d.

3170. **Leclanche cells.** Rylands. 6d.

3239. **Electric conduits.** Raworth and others. 6d.

3269. **Mechanical telephones.** Dunlap. 6d.

3383. **Dynamo-electric machines.** Kingdon. 8d.

3592. **Electric alarm apparatus.** Whitehead. 6d.

14796. **Electric meters.** Abel. (La Compagnie Anonyme Continentales pour la Fabrication des Compteus à Gaz et Autres Appareils.) 8d.

15937. **Electrical measuring instruments.** Fell. (Weston.) 6d.

16388. **Arc lamp.** Hays. 6d.

19900. **Welding metals electrically.** Thompson. (Coffin.) 6d.

20215. **Electrical machines.** Harness. 8d.

20257. **Electric lamps.** Thompson. (La Compagnie de l'Industrie Electrique.) 6d.

NEW COMPANIES REGISTERED.

Reading Electric Supply Company, Limited.—Registered by H. F. Kite, 11, Queen Victoria-street, E.C. (for H. Collins, Reading), with a capital of £75,000 in 15,000 shares of £5 each. Object: to acquire, as a going concern, the business now carried on by the Laing, Wharton, and Down Construction Syndicate at Reading, Berkshire, under the style of the Reading Electric Light Depôt, and generally to carry on the business of an electric supply company in all its branches, as electricians and mechanical engineers, the promotion and financing of companies, and the general business of a financial agency. The first subscribers are:

	Shares.
J. Wharton, 30, Parliament-street, S.W.	1
J. Ireland, 13, Minch-avenue, Harlesden	1
H. Lee, 27, Garfield-road, Lavender-hill	1
W. Jones, 87, Balfour-road, Highbury New-park, N.	1
E. Carpenter, Johnson Villa, Gleneagle-road, Streatham	1
E. W. Piper, 37, Vernon-road, Bow, E.	1
G. H. Wise, 14, Silverton-road, East Dulwich	1

Registered without special articles of association.

BUSINESS NOTES.

City and South London Railway.—The receipts for the week ending 24th inst. were £811, against £743 in the corresponding period of 1891, being an increase of £68. As compared with the week ending Jan. 17th, the receipts for last week show a decrease of £25.

Newcastle Electric Supply Company.—The annual general meeting of this Company was held on Monday at Newcastle. The report and balance-sheet were adopted, and a dividend at the rate of 4 per cent. per annum was declared for the year ending 31st December, 1891.

A Big Dividend.—At the annual meeting of Messrs. J. E. H. Gordon and Co., Limited, electrical engineers and contractors, 11, Pall-mall, held on 25th inst., a dividend of 30 per cent. was declared on the paid-up capital of £50,000, and a balance of £4,535 was carried to reserve.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3½
— Pref.	—	2⅜
India Rubber, Gutta Percha & Telegraph Co.	10	19½
House-to-House	5	5
Metropolitan Electric Supply	—	9⅝
London Electric Supply	5	1¼
Swan United	3½	4
St. James'	—	9
National Telephone	5	4⅜
Electric Construction	10	6½
Westminster Electric	—	7⅛
Liverpool Electric Supply	5	5
	3	2⅞

NOTES.

Brindisi.—A telephone exchange has just been opened at this celebrated seaport town.

Budapest.—The transformer system only is to be used for the electric lighting of Budapest.

Dalton (Lancs.).—The Dalton Local Board have terminated their contract with the Gas Company.

Electro-Harmonic.—A smoking concert is held to-night (Friday) at the St. James's Restaurant, Regent-street.

World's Fair.—The Thomson-Houston Company will spend half a million dollars on their exhibit at the World's Fair.

Almanack.—We have received a handsome coloured perpetual almanack from Messrs. Woodhouse and Rawson, United.

Rapid Transit.—Pueblo, Colorado, has a complete system of electric railways—length 22 miles—which cost £120,000.

St. Petersburg.—The electrical exhibition at St. Petersburg, which opened last week, was attended by Mr. Edison.

Ipswich.—The Board of Trade have revoked the electric lighting order, 1891, of Messrs. Laurence, Scott, and Co., as asked by the promoters.

Electric Traction.—A large combination is being formed for the introduction of electric traction in Paris and the other large towns of France.

Thomson-Houston Lines.—The Thomson-Houston Company has installed 63 new electric roads, says the N.Y. *Electrical Review*, this year—rather quick work !

Royal Institution.—The Right Hon. Lord Rayleigh, F.R.S., will, on Saturday, February 13, begin a course of six lectures on "Matter: at Rest and in Motion."

Walton-on-Naze. — The Walton-on-Naze Sanitary Committee have the question of the purchase of gas works or other settlement of the lighting question before them.

Royal Institution.—Prof. Fleming will give the third of his lectures on "The Induction Coil and the Transformer" on Saturday, at 3 p.m., at the Royal Institution.

Train Lighting. — The Simplon Railway Company have arranged to light 50 of their carriages by electric light, the current to be obtained from Huber accumulators.

Electric Terminology.—The last electrical term, says *Industries*, is "hindrance." It amusingly suggests that perhaps hindrance, like other electric terms, is, in reality, a velocity !

Sofia.—The Mayor of Sofia has decided that the tenders for canalisation of Sofia are to bear mottoes or devices only, and the time for sending in has been extended to March 3.

Taunton.—Local opinion as regards the proposed purchase of the town seems to be in favour of letting the Taunton electric works continue yet awhile, and further demonstrate their success.

Gas Engines.—The next meeting of the Junior Engineering Society will be held on Friday, February 12, at the Westminster Palace Hotel, at 8 p.m., when a paper will be read on "The Gas Engine," by Mr. E. G. Walker.

Italian Telephone Lines.—A telephone line, the first that unites two Italian cities, has been opened at Milan, establishing telephonic communication between that city and Pavia. It is more than 30 miles long, and acts perfectly.

Bath.—During three months the lamps at Bath were out 244 hours, and the amount at 1½d. an hour, £1. 10s. 6d., was deducted from the public lighting bill. The committee have sanctioned the expenditure of £28 in testing instruments.

Bermondsey.—At the meeting of the Bermondsey Vestry last week, the General Purposes Committee reported that they had instructed the surveyor to obtain terms for lighting the streets from March 25th next, which course was approved.

Physical Society.—At the Science Schools, South Kensington, to-day (Friday), at 5 p.m., Prof. G. F. FitzGerald will read a paper before the Physical Society on "The Driving of Electromagnetic Vibrations by Electromagnetic and Electrostatic Engines."

Antwerp.—The contract recently concluded by the Antwerp Corporation with MM. Moris et Von Rysselberghe for public lighting on the "hydro-electric" system, requires a guarantee fund of £40,000. The light is to be supplied at less than the present price of gas.

Manchester. — The Manchester shopkeepers are becoming anxious to get the light at once, and Mr. Brooks, at the last City Council meeting, had to assure a questioner that no time was being lost, some of the contracts being already in hand, including those for engines and boilers.

Shoreditch.—The Shoreditch Board of Guardians have appointed a committee of five members to act with Mr. Smith, their architect, who has had several establishments fitted with electric light under his charge, to visit these installations and report upon the best scheme for lighting the workhouse.

Ice Carnival.—At the Theatre Scribe, Turin, on Wednesday, a white ball was given, the whole house being decorated with wintry scenery—ice, snow, glaciers, and all the picturesque accompaniments of the season. Moonlight was imitated by the electric light. All the ladies were dressed in pure white.

Utilisation of Water Power.— The Mulhouse Industrial Society, Alsace, have offered a premium of £100 for the best scheme of utilising natural water power, specially applicable to the needs of Upper Alsace. Projects, accompanied by sealed envelope containing name, must reach the society by May 15th.

Chicago Applications.—Intending exhibitors must not tarry if they mean to obtain space at the World's Fair. The date fixed for receipt of applications is the 29th of February, and after that date applications can only be received subject to space being available. The London office is at the Society of Arts, Adelphi.

Institution.—On Thursday next, Feb. 11, a paper will be given before the Institution of Electrical Engineers by Alexander Siemens, vice president, on "Some Experimental Investigations of Alternate Currents." The discussion on the above and Mr. Preece's paper on the "Specification of Conductors," will be held on the same evening.

Denbigh.—The Town Council of Denbigh have had the question of the purchase of the gas works brought before them. Mr. Howel Gee thinks Denbigh well situated for lighting by electricity, and it is to be hoped he will be supported. The Mayor is to draw up a report of the cost of the scheme for public control of the lighting.

Tewkesbury.— The Tewkesbury Urban Authority have before them the question of applying for a provisional order for the supply of electric light, and the clerk has been instructed to make enquiries. There should be the

possibility of utilising the power of the Avon or Severn, we fancy, for generating of light for Tewkesbury.

Electric Welding.—Mr. Coffin, of Detroit, proposes to weld electrically by a combination of arc and incandescent systems, first making his joint hot by contact with a conductor, and simultaneously springing an arc between the said conductor and another near the point of contact, welding the metal when at the desired temperature.

A New Alternator.—The Helios Company have recently patented a peculiar dynamo, having a long armature and two sets of field magnets. At one end of the armature these are placed above and below, and at the other end at the sides. The dynamo is apparently to be used for generating alternating currents varying in phase for transmission of power.

Portsmouth.—The Portsmouth Town Council on Tuesday revoked its previous decision to light the town with electricity on the low-tension principle, and adopted a new high-tension scheme, estimated to cost £38,000. An amendment for deferring the scheme until the question of using tidal power for machinery was considered was lost by the Mayor's casting vote.

Llanelly.—At the meeting of the Llanelly Local Board held on Monday, the question of electric lighting of the town arose out of the minutes of the previous meeting. It was remarked that if the Board intended to take advantage of the provisional order, something should be done at once. The clerk stated that the Board had already determined to advertise for tenders.

Cork Tramways.—The Cork Corporation have adopted the recommendation of the Standing Committee that, subject to plans being approved and other conditions deemed advisable, the Corporation give general approval of the proposed scheme of street tramways. We believe there is some idea of running these trams by electric traction if suitable arrangements can be made.

Society of Arts.—The third of Prof. Forbes's Cantor lecture, on "Electrical Distribution," will take place on Monday next, at 8 p.m., at the Society of Arts, when the following will be dealt with: Transmission and distribution of electricity derived from lighting circuits; effect on load factor; separate circuits for power; distribution for street and other railways; utilisation of water power by electric transmission to a distance.

Pontypridd.—The proposal is before the Pontypridd Local Board to purchase the gas works, the gas company being willing to sell or extend their works as the case may be. The Pontypridd Electric Lighting Company have offered to light the centre of the town by electric light, and the clerk was instructed to obtain particulars of the success or otherwise of Taunton. We hope the result will be a central station for Pontypridd.

Schanschieff Batteries.—A correspondent writes that, instead of costing 7s. 6d. per unit, these batteries can produce electrical energy at 2s. 6d. per unit, "and hopes with careful experiment and better management" to reduce the price still further. The same correspondent points out that the proposed capital of £50,000 consists of £5,000 cash and £45,000 paper—the latter going to the vendor, who receives nothing till 10 per cent. has been paid on the £5,000.

Milk Ivory.—According to a recent note in the *Chemical Trades Journal*, it appears that a substance termed "lactitis," much like ivory, is now made out of milk. Curds are taken, mixed with borax and a mineral salt, such as sugar of lead, blue vitriol or other, and pressed with great force. The resulting mass is hard and resisting, *capable of* replacing ivory, celluloid, and ebonite, though being an animal substance its electrical resistance will probably be low.

Cyclometer.—Ransome's cyclometer for showing the variations of speed in the motors used for electric lighting is made by Messrs. Manlove, Alliott, and Co., of Nottingham. It is capable of representing the fluctuations of speed during a single revolution of the motor-shaft, and hence of indicating whether or not the flywheel is heavy enough. The intervals of time are measured by a vibrating tuning-fork, which by means of a stylus describes a wavy line on a revolving barrel of smoked paper.

Sea Telephone.—The question of telephoning between ships at sea is evidently one which is exercising the brains of inventors. We mentioned Edison's plan last week, and we notice that an elaborate patent has been taken out by Ernst Huber and Fred. J. Kneuper, of New York, for an instrument similar in its aims, but which, apparently by means of "sound-interceptors," is to register sound vibrations transmitted through the water, part of the apparatus dipping into the sea below the ship.

Springfield (Essex).—A public meeting was held recently with reference to the public lighting of Springfield by electricity, and Mr. T. H. Dennis undertook to see Messrs. Crompton and Co. with a view to obtaining an installation. Messrs. Crompton wrote that they could not undertake the public lighting alone, but if there were private consumers they might make an offer. A canvass has been made, and it is thought there is a fair chance of the light being adopted. Messrs. Christy and Norris have also made a canvass.

Life Belt Cushions.—The "Combinare" cushions, made by Mr. T. Steward, at 32, Gray's-inn-road, are worth attention by all interested in naval matters. They are suitable for boats and ships of every description, and in case of need form most efficient life buoys. They are lighter than cork, and impervious to damp. They are being taken up largely by the British and also foreign Governments, and we understand that the General Electric Traction Company will replace all their boat cushions with this "Combinare" cushion

New Insulating Material.—A novel and permanent insulating material for electric wires and cables forms the subject of a patent by Mr. Thomson Griffiths, F.C.S., of Dashwood House, City, the well-known authority on pigments. By this invention, it is said, a saving is effected of about 50 per cent. over those in use. It is stated to be not only of a most durable and permanent character, but that the insulating power of the cables and wires is greatly increased, while the mode of application is extremely simple and inexpensive.

Liverpool.—A numerously signed memorial was read at the Liverpool City Council requesting the Council to give their consent to the application by the Liverpool Electric Supply Company for a provisional order whereby the company would be bound to reduce the price to 8d. per unit. Mr. Hornby stated that the Council were determined to oppose the application, as under the 1889 orde they had power to buy up the most important part of the undertaking in 19 years, and they would not give up this power without some considerable concession.

Camberwell.—At the last meeting of the Camberwell Vestry the General Purposes Committee, through Mr. Wallace, reported the receipt of a letter from the engineer of the Camberwell and Islington Electric Light and Power Supply, Limited, formally acquainting the Vestry with the information that their Bill passed both Houses of Parliament last session, and received the Royal assent; also that the company had made the deposit of £2,000 required by the Board of Trade, and that it was anticipated that the

new system of lighting would be inaugurated early this year.

Cable to Lundy Island.—Public attention has lately been called to Lundy by H.M.S. "Banterer," and much surprise has been expressed that a much-frequented harbour of refuge should have no telegraphic communication. A cable was laid in 1884, but did not receive sufficient support, and the cable was sold to Mr. Rogers, the maker of it, who has removed it to London. If a new cable is laid, it is thought better to lay it to Braunton, seven miles extra, when the Chamber of Commerce would subsidise the company. The old cable is still available, and could be relaid at small cost.

Hastings Company.—At the annual meeting of the Hastings and St. Leonard Electric Light Company, recently held, the chairman said the respectable dividend of 7½ per cent. was declared in the report, this leaving a balance of £320 over. He reminded them that last year the directors had not only given their services, but made themselves responsible for debts. He thought £200 was not too much to be given to the directors, leaving £120 to be carried forward. He passed a word of sympathy for nervous shareholders who had sold their £10 shares for 25s. after what was said in the papers. The report and the chairman's recommendation was adopted.

Electric Lifts for Railways.—The use of electric motors for lifts and drawbridges has achieved sufficient success for there to be any doubt of the possibility of their use in moving large weights when so required. In the City and South London Railway, as will be remembered, the lifts which carry the passengers to and from the ground level are hydraulic lifts, but we have reason to believe that on the newer ventures, such as the Central London electric road, electric lifts will be used. This will, of course, do away with the necessity for separate generating plant and distributing mains, and will simplify the station arrangements considerably.

Electricity from Wind Power.—At the last meeting of the Royal Scottish Society of Arts, Prof. Blyth, of the Anderson College, Glasgow, read a paper on the "Utilisation of Wind Power for the Generation of Electric Light." After alluding to his previous experiments, Prof. Blyth stated that last summer he had used a machine on the principle of the Robinson anemometer, with hollow cups, rotating horizontally. It worked satisfactorily, and in a fair wind gave out 4 e.h.p. Even in a gale it ran satisfactorily. Prof. Blyth is an ardent supporter of the use of wind power for electric light, and his example should stimulate others to follow his and Mr. C. F. Brush's example. It will be remembered that Mr. Brush has a "wind turbine" in his garden for supplying his electric light.

Budapest Electric Tramway.—The success that has attended the introduction of electric traction into the streets of Budapest is a good augury for the extension of electric railways in Europe. It will be remembered that this line is upon the open-slotted conduit system, more particularly advocated in this country by Mr. Edward Manville. The Budapest railway was equipped by Messrs. Siemens and Halske, who deserve great credit for the success achieved. The mileage has lately been increased from 5½ to seven miles, most of which is double track. They now have 62 cars in use, and the mileage last year attained 24,000 miles, double that of the previous year. The power of the generating station now amounts to 700 h.p. The number of passengers carried last year is given as 8,619,215, as against 4,459,234 in 1890.

Chiswick.—At the last meeting of the Chiswick Local Board, Mr. Harry Smith moved, in accordance with notice, "That instructions be given to the surveyor to enquire and report as to the persons desiring a supply of electric light in this parish." Mr. Smith pointed out that there was a company willing to introduce electric light into the parish providing they could obtain a sufficient number of consumers. He thought that a majority of the inhabitants were in favour of the electric light, and he would propose that a memorial be drafted and the ratepayers canvassed. Mr. Adamson suggested that they might draft a circular and ask the ratepayers to sign it. In reply to the chairman, Mr. Smith said that the cost of the electric light would be about one-third more than that of gas. The arrangements for canvassing were left in the hands of the clerk.

Ventilation and Lighting.—Besides electrical contractors and the householder himself there is one class of professional man to whom a good knowledge of the advantages of electric light is worth money—and this is the sanitary engineers, who have often to advise upon the internal arrangements of high-class dwellings. We are pleased to see that at one of the lectures for sanitary officers held at the Parkes Museum in connection with the Sanitary Institute, the question of electric lighting was dealt with by Sir W. Douglas Galton, his subject being ventilation, warming, and lighting. After describing methods for changing the air in rooms, the question of impurities from illuminants was gone into, oil being recommended as preferable to gas both as regards products of combustion and amount of heat. But the only really hygienic light was the electric light. Sanitary engineers are rapidly recognising this fact, and Sir Douglas Galton's lecture will probably turn still greater attention to the necessity of considering hygienics as well as light in household illuminants.

Liverpool Electric Football Club.—The above football club held their second annual dinner at The Eagle Restaurant, Liverpool, on Saturday last. The dinner was preceded in the afternoon by a football match between the married and single members of the club, which the benedicts won by four goals to one, reversing last year's verdict, when the single men won by five goals to nil. In the evening the party, numbering about 80, included Mr. A. B. Holmes, managing engineer of the Liverpool Electric Supply Company, Limited, Mr. B. H. Collins, secretary, Mr. A. Clough, works manager, and Mr. Naftel, chief electrician. The dinner was followed by a miscellaneous entertainment. The proceedings commenced with a pianoforte solo and banjo song, after which Mr. Collins proposed the toast of "Success to the Liverpool Electric Supply Company, Limited," to which Mr. Holmes responded, referring to the progress of the company since its formation and its present satisfactory condition. Songs and instrumental music interspersed with toasts occupied the remainder of the evening, which was brought to a close by the singing of "Auld Lang Syne" and "God save the Queen."

Sims-Edison Torpedo.—On Wednesday an official trial of the Sims-Edison torpedo by the military authorities took place at Portsmouth before the Duke of Connaught, Major-General Geary, and others, who went out to the "Drudge," a steam vessel lent for the purpose of the test by the Elswick Company. Mr. Sims, Captain Hamilton, and Major Palliser, directors of the Sims-Edison Company, attended. The torpedo, it will be remembered, is driven and controlled by two electric wires from a dynamo, the body is submerged, and two flagstaffs show the direction of movement. In the test, the torpedo was first sent by Mr. Sims at right angles to the ship at a speed of about 10 knots. When three-quarters of a mile off the torpedo crossed the bows

and described a semi-circle, at a speed of 16 or 17 knots against tide, and in a choppy sea, in which it was frequently submerged. Having run out 7,000ft. of wire inside the torpedo and another 4,000ft. on board the ship, it was brought to a dead stop as if for exploding. The advantages claimed are that the Sims-Edison torpedo is controllable at any distance within its range, without the necessity for other fixed plant than switches and dynamo—the ordinary lighting dynamos of some of the large battleships giving ample current.

Aston Baths.—The Baths Committee of the Aston Local Board report that they have had under consideration the question of the lighting of the public baths. They are advised that there will be sufficient engine power to generate electricity for the public baths, and also for the Public Buildings. The committee have obtained tenders for the electrical installation of the public baths and also the Public Buildings. In discussing these tenders, the committee state that, notwithstanding the initial outlay for dynamos, storage batteries, cables, wiring, fittings, etc., the electric light can be substituted for gas and a saving effected of £74 per annum, which at 4 per cent. per annum, the interest on a capital sum of £1,850, would be a clear saving as compared with the cost of lighting by gas. From this amount some allowance should be made for depreciation of plant and towards the cost of attendants' wages, etc., but at present it is impossible to accurately fix this amount. In the circumstances the committee unanimously recommend the Board to adopt the electric light for the public baths, and to substitute this mode of lighting for gas at the Public Buildings, and that the tender of Messrs. Fowler, Lancaster, and Co. for the execution of the work, at the sum of £1,594, with the sum of £30 per annum for the maintenance for a period of five years, be accepted.

Electric Light at the World's Fair.—Some 50 separate contracts are to be let for the electric lighting of the Chicago Exposition buildings and grounds. In all there will be used, according to present plans, approximately 127,000 electric lamps, of which 7,000 will be arc, of 2,000 c.p. each, and 120,000 incandescent 16-c.p. lamps. To run the plant, 22,000 h.p. will be required. By the awarding of separate contracts for the lighting of each of the buildings and of different sections of the grounds, all electric firms, whether large or small, have an opportunity to participate and to show what they can do, and at the same time a variety in illumination will be effected. One of the distinctive features of the electrical display will be that made in the main basin. Special attention will be given to the illumination of this basin, and it will be encircled by 1,650 incandescent lamps. The lamps are to be 2ft. apart and 3ft. above the surface of the water of the basin. In the great Manufactures Building alone there will be 33,000 lights. The plans prepared by the electrical experts call for ten times the capacity of all the plants used at the Paris Exposition. The World's Fair directors will spend 1,000,000dols., and perhaps more, for these electric plants. Exhibitors will not be required to pay anything for light, except in cases where they call for more lamps than are furnished by the construction department. In that event, they will be furnished additional lamps at actual cost. Electric power will be conveyed over the grounds in a system of underground conduits. Some of the wires will, however, be hung from the structure of the elevated railroad.

London Provisional Orders.—The Highways Committee of the London County Council report that they have had before them seven provisional orders for which application has been made by the Board of Trade. These are as follows: 1. County of London, North (parishes of Islington, Clerkenwell, and St. Luke; Holborn district). 2. County of London, South (parishes of Lambeth and St. George-the-Martyr; Wandsworth district). 3. East London (Hackney district). 4. North London (Hackney district; parishes of St. Luke and Clerkenwell). 5. St. Mary, Islington (parish of Islington). 6. South London (St. Olave's and St. Saviour's districts; parishes of St. George-the-Martyr and Newington). 7. West London (parishes of Hammersmith, Fulham, and Battersea; and part of Wandsworth district). The committee have submitted certain amendments to the Board of Trade, and informed the Board that where powers are sought over the same area by the local authority and by a company, their opinion is that the former should be preferred. They have also considered a model order (form No. IV.), forwarded by the Board of Trade for the Council's observations, for use in cases where the local authorities are the undertakers. There are four of these orders applied for this session—viz., Hampstead, Lambeth, Shoreditch, and Whitechapel district orders. They have directed that certain amendments, which they think necessary in order to make the form of order correspond with previous legislation, shall be submitted to the Board of Trade, these amendments relating principally to the insertion of clauses relative to the keeping of separate accounts, removal of existing overhead lines, inspectors' fees, protection of the Council's works, regulation of price, and so forth. They also report that formal notice of the revocation of the Wandsworth district order has been received from the Board of Trade.

Priority and Cost.—The following interesting letter written by Mr. John Sellon to *Lightning*, in answer to a question as to the first house lighted by electricity, deals suggestively with the cost of the electric light, and is worthy of extended quotation by electric light promoters: "I commenced wiring my house early in 1881; at Easter of that year my electric light shed was completed, and I was soon afterwards running my lights with a Schuckert dynamo, which I had by me for experimental work—later on replaced by a Brush. The wiring was carried out entirely under my own supervision, and as suitable fittings for the light and even good switches and other details were then unknown or unprocurable, I had all mine made by workmen of my own, the ornamental glass work being also specially made for me after my own designs. As they were then—1881—so in the main they are now, 120 lamps throughout the house from top to bottom, every room and every outhouse being so lighted. I naturally experienced at first some troubles and annoyances, chiefly from flickering of the light, and the necessity of running the dynamo all the time that any light was needed. It was these inconveniences which induced me to turn my attention to secondary batteries, my first patent for which was taken out in September of that year. After some crude attempts, I at last, quite early in 1882, was running my entire system with accumulators, almost as perfectly as it runs to-day. I have made no material alteration or addition since that time, meanwhile my lighting has been entirely free from interruption, beyond a few hours when altering or changing the accumulators, and a short stoppage or two through failure of the supply of gas for my engine. The saving to me directly and (but of course chiefly) indirectly, I consider to have been close upon £100 a year throughout the decade, during which the ceilings and decorations of all the principal rooms have not been even touched up, and they at present shows no signs of wanting it, while the comfort enjoyed has been beyond estimate."

OUR PORTRAITS.

Eason, W. B., born in 1858, is a native of Aberdeen, in which town he received his early education, but after three years' apprenticeship in the engineering works of Messrs. McKinnon and Co., attended the Royal School of Mines lectures in engineering. After more practical engineering experience at the Thames Iron Works, Mr. Eason attended Prof. Ayrton's lectures at Finsbury, when his introduction to the electrical world may be said to have taken place. In 1883 he went to Messrs. Paterson and Cooper as electrician, and soon after became manager. With this firm he still remains, and it is not too much to say that the extension of the firm's work in various directions is due entirely to the energy and ability of the manager. Mr. Eason has a three-sided character—he is a worker, a thinker, and a good companion. We hardly know what more can be required of a man. His contributions to the technical journals and to the Institution's *Proceedings* are always of a very practical nature, and mark him as one of the leaders in the profession. That he is ever ready to help beginners is well shown by the work he has done for the Old Students, of which society he was re-elected president for the current year.

Baker, Sir B., is known better in connection with the Forth Bridge and other works of a similar character rather than as an electrical engineer, although he is one of the recent elections upon the rolls of the Institution of Electrical Engineers. Sir B. Baker's early training was that of a mechanical engineer, with a subsequent extensive experience in the work of a civil engineer. After his arrival in London he entered Sir John Fowler's office, and gradually took a more and more active part in the many engineering works carried out from this office, including, amongst others, the Metropolitan Railway. But, as we say, it is his connection with the Forth Bridge that looms most conspicuously before us. Of this great work we have no occasion to speak, but it may be noticed that Sir B. Baker called electricity to his aid in carrying out the work. He is a member of most of the great engineering societies, and has largely contributed to the literature of this subject.

Binswanger, Gustav. Born in Bavaria in 1855, and received his education at the Polyteknikum, Augsburg. He has resided in England since 1873, becoming naturalised in 1879, when he began business as electrical engineer and manufacturer of electrical apparatus. The factories and business establishments which he has conducted since that period have experienced a rapid growth and extension, in keeping with the increase of electric lighting and telephonic business in general. At Mr. Binswanger's first factory at Homerton the number of hands employed was about 10; his works at Chapel street, Manchester, now employ from 500 to 600 workpeople, and the employés engaged in electric work at the head office in Queen Victoria-street, and the branch warehouse in Great Saint Thomas Apostle, at Glasgow, Melbourne, and Cape Town number about 200. To Mr. Binswanger's efforts and business and technical capacity are due a number of improvements in the use of electricity for lighting, motive power, and heating. We will mention only his early introduction of electricity meters, his improvements of electric fittings, such as switches, roses, connectors, etc., his introduction of electric motors for domestic purposes, and his system of electric heating by the process of embedding platino-iridium resistances in layers of enamel. Mr. Binswanger's attention was also given at an early date to telephony and electric signalling, and the position which his house holds in this branch of applied electricity testifies to the success which has attended his efforts. Mr. Binswanger has issued a great many effectively illustrated catalogues, mainly with the object of popularising electric lighting and telephony, and throughout his career in connection with electrical enterprises his main effort has been to induce the general trade of engineers, gas engineers, plumbers, etc., to introduce electric lighting, and thus make it known and popular in districts and places where the establishment of a purely electrical enterprise could not have been a pecuniary success. Mr. Binswanger is principal proprietor and managing director of the General Electric Company He is a member of the Institution of Electrical Engineers, Fellow of the Society of Arts, and on the Council of the Electrical Section of the London Chamber of Commerce.

Grindle, G. A. Educated privately, and afterwards at Oxford. In 1876 entered the School of Telegraphy and went through a course, and subsequently visited India and America, returning 1880. In the same year entered the service of the Anglo-American Brush Company, passing through the shops, and carried out several installations for them, finally taking charge of the City of London experimental lighting (Brush section) 1881. In 1881 was appointed chief electrical engineer to the Eastern Electric Light and Power Company, Limited, and proceeded to Egypt, where he carried out several installations until compelled to leave at outbreak of Anglo-Egyptian War. Returned to England, and for several months was engaged experimenting for Eastern Electric Light and Power and Indian and Oriental Storage and Electrical Works Companies, Limited, conjointly, chiefly on storage batteries, then proceeded to Bombay to take charge of the Eastern Electric Light Company's operations in India, where he carried out numerous installations. Returned to England in 1884, and was appointed manager to Belfast Electrical Appliances Company, erecting for them various important installations in Ireland. In 1886 entered into private practice in London, and in 1889 was appointed resident engineer for Messrs. Mather and Platt on the City and South London Railway undertaking. He now remains in Messrs. Mather and Platt's service.

Wallace, R. W. Born in 1854. Educated privately. Graduated at London University: is a well-known barrister, who was called to the bar in 1884. Director of Kensington and Knightsbridge Electric Light Company, and of the Westminster Company. Has been counsel in many important engineering and chemical cases, such as Kirk and Randall *v.* East and West India Docks, Nettlefolds *v.* American Screw Company, Rawes *v.* Chance Bros. (alkali recovery); in electrical matters mostly for electrical companies; in Edison feeder patents; at present in Lane Fox *v.* Kensington Company, and Hopkinson *v.* St. James's Company. Author of a work on patent law. Associate member of the Council of Electrical Engineers. Before called to the bar he was inventor of many important processes in the manufacture of chemical products, and in processes for gas purification. He was engaged as counsel for a large number of electrical companies before Major Marindin, when London was divided up for electrical purposes. He is working at present with the Duke of Marlborough in improving the telephone service in the United Kingdom, a work which it is devoutly hoped will be successful, for there is great need of such improvement.

CRYSTAL PALACE.

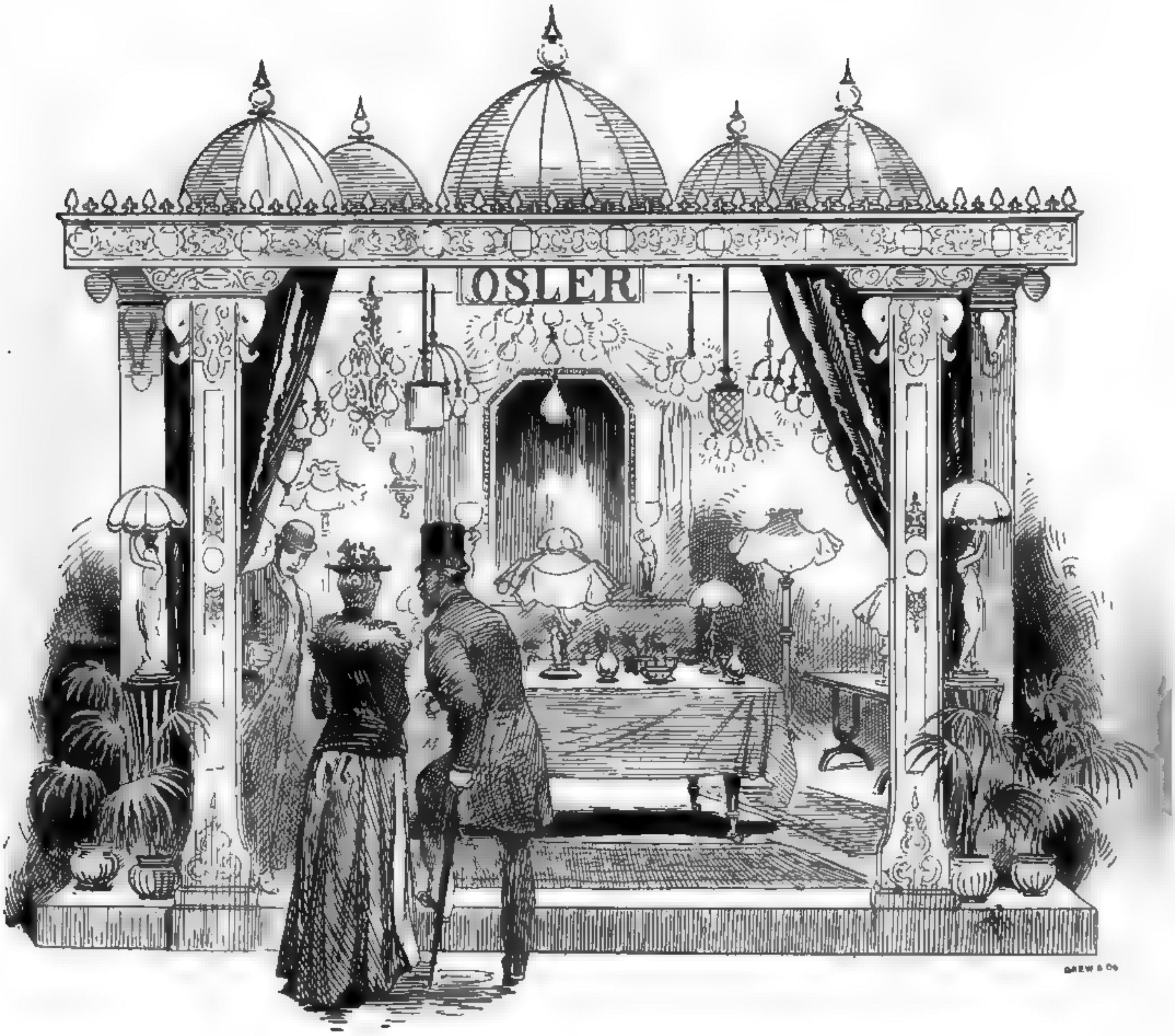
The Lord Mayor and Lady Mayoress are to visit the Crystal Palace to-morrow, and the Exhibition, which has already been opened without ceremony, will have additional attention called to it in the minds of the public after this public function. Many persons have put off paying even a preliminary visit, hearing that the exhibits were not ready, but the whole Exhibition is now practically in shape. Almost all the stands are complete, and those that are not only requiring a last few finishing touches; the machinery is nearly all in running order, and what may be termed the side shows—such as Messrs. Siemens's model theatre, the high-tension experiments, the drills, electric lifts, electric cooking, the Edison-Swan screen, and so forth—are now or will be in working order on Saturday, and regularly from the beginning of next week.

Messrs. Crompton and Co., have had their crane going this week—travelling, slewing, hoisting—the current being supplied from their own dynamos. Inner rails have been laid, covered with thick strip copper, which conduct the current. It is necessary, by the way, to remark that the speed of hoisting of this crane is two tons 80ft. per minute—and not per second, as given in a former notice,

which would be at the rate of nearly a mile a minute. In action this crane will be a constant centre of attraction, demonstrating the possibilities of the use of electric power.

When the incandescent lamp came into vogue there was much discussion as to what was the proper class of fitting to adopt for it. The lamp was so dainty, delicate, and fairylike, that it made the heavy coarse gas fittings look grotesque. Evidently designers must begin over again. Among those who have resolutely set themselves to forget all about gas and its fittings are **Messrs. Osler,** of 100, Oxford-street, W., who have struck out quite a new line. They have gone to Dame Nature for advice, and have adopted one of her most graceful productions as their model—we refer to the fuschia. Not only so, but discarding metal they have adopted cut glass as the material of their fittings. As to the effect of this departure our readers can judge for themselves by paying a visit to Messrs. Osler's stand (No. 5), which is certainly in its way one of the attractions of the Exhibition.

The structure has been designed in the Eastern style, the top being surmounted by domes, and supported by pillars. The decorations are in keeping with the structure, and altogether the firm make an attractive show. The centre dome is lighted by a very handsome 25-light electrolier in cut glass and polished brass. A draped mirror surmounts a mantel-piece, on which stand Grecian figures in Worcester porcelain, which have been specially designed by the Royal Worcester Porcelain Company. Here also are vases in cut glass having incandescent lamps inside, and giving a very pretty effect. In various parts of the stand are electric standards in cut glass, brass, and china, the workmanship of which is sure to be admired. The stand is handsomely draped with curtains. Between the columns which support the roof at the front of the stand are two Grecian figures, one on either side, carrying lamps with specially-designed shades. The figures are of Worcester porcelain, and are remarkably graceful. On a table in one corner are some flower-stands of special design in cut glass, fitted with one or more lamps. Ladies should be able to produce some very pretty effects with these stands. Another standard for tables has a centre-piece for holding the lamp, while below are receptacles for flowers. In the centre of the apartment is a table specially decorated and arranged to show the simple way in which the electric light can be used for this purpose. The floor is covered with Eastern matting, over which are laid Oriental rugs. The sketch which we publish herewith will give those of our readers who have not seen the Exhibition a very good idea of Messrs. Osler's stand.

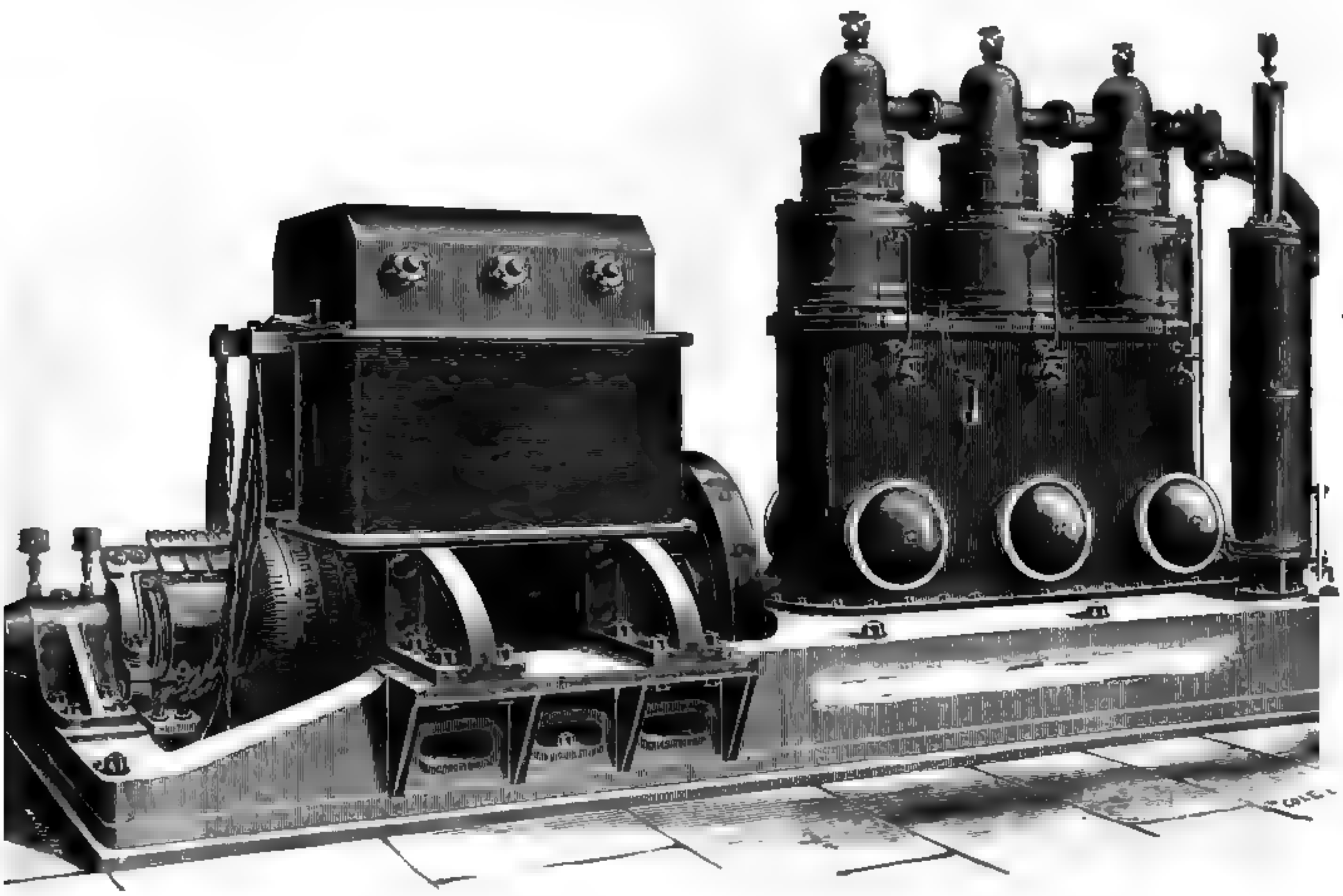


Sketch of Messrs. Osler's Stand at the Crystal Palace Exhibition.

The General Electric Company have a peculiarly original stand to themselves in the centre of the South Nave. Its tall pyramid, or Cleopatra's needle, with four sides made of thousands of switches, cut-outs, ceiling roses, and wall sockets, can be seen from afar down the transept, and fitly symbolises the company's position as wholesale makers of these most necessary fittings for house adornment by electric light. Large mirrors give an imposing appearance to the base of this stand, around which are crowded a plethora of electrical apparatus, instruments, telephones, batteries, bells in variety too numerous to mention. Standing around

are a number of interesting examples of the use of small electric motors for easing household labour, and boot-blacking machines, knife-cleaning machines, churns, fans, pumps, and so forth, will all be shown working. But perhaps the most interesting feature of this stand will be the electric cooking and heating apparatus. The Lady Mayoress is to be presented with a steaming hot pancake baked by electricity, with the apparatus made by this company, and the Lord Mayor may have his hat ironed by an electric heater if he so desires. Flexible wires connected to a wall socket serve to carry all the current that is needed. In the case of the electric cooker this current is about three amperes at 100 volts, and this is sufficient to heat three hot-plates for baking or grilling. Electric foot warmers and car or room heaters will also be shown, and it may confidently be expected that the continual demonstration of the cleanliness, simplicity, and ease of application of electric heating at the Exhibition will cause many persons to have it adapted to their houses along with the electric light.

avoid all this, and show at one glance the direction a vessel carrying it is steering. It is a simple but highly-ingenious arrangement. A strong lamp is placed inside a glass case, which is shaped somewhat like a small bath placed edgeways, that is, having the front circular plate smaller than the back one, the sides being of opal glass. The front and back plates are opaque, but a large cross is left on the back plate. The effect of this simple case for the lamp is, that when the ship is coming straight end on towards a person, a round ring of light is seen; if the vessel steers to port or starboard a crescent of white light is seen, the horns pointing in the direction that the vessel is approaching. When going direct away the cross is seen, and in other positions, combinations of ring, crescent, rectangle, and cross are given, visible by the eye at a mile away, and with a glass at two miles, giving an immediate indication of the vessel's direction. When it is remembered that nearly a third of the casualties at sea occur from collisions, that this is the captain's greatest dread, that the sudden appear-



Siemens Central Station Set of Dynamo and Triple Compound Engine.

In the very centre of the Palace, in front of the orchestra, a wide and deep space in the floor has been fitted up as a beautiful underground grotto with fountain. This is to be lighted by electric light by **Messrs. Laing, Wharton, and Down**, and the fairy lamps will enticingly glitter and glisten amongst sparkling showers on rock and ferns springing up from the centre of the floor.

There are two novelties which we noticed at our last visit to the Exhibition which are worthy of particular attention. One of these is a new lamp for the better direction of ships' courses at sea, and specially for the avoidance of collision—termed the Crescent Course Indicator, the invention of **Mr. J. Fletcher Wiles**, of Lloyd's, Royal Exchange, and Crescent Works, South Croydon. As is known, the ship's lights usually consist of a red and green light. This arrangement, although until the present nothing better has been suggested, suffers from two defects: First, the green light does not always show as far as the red from difference in penetrating power; and secondly, and more important, the captain on another vessel cannot be certain of the *direction* in which the ship is going until one of the two lights disappears, sometimes too late to avert a catastrophe. The Crescent indicator is to

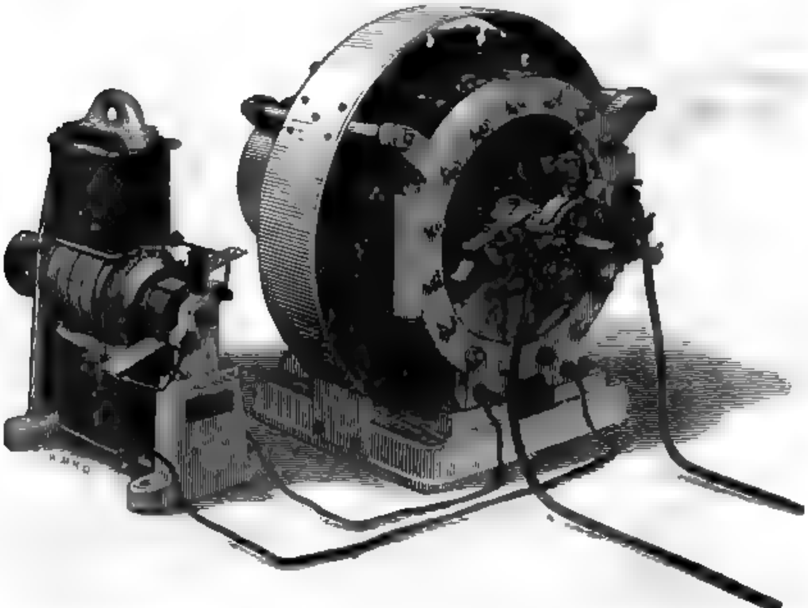
ance of lights in a fog do not now enable a captain to give his orders without a few moment's delay to ascertain the strange vessel's direction—moments that mean all the difference between a collision or otherwise; when it is stated that many companies only ensure their vessels against collision, taking all other risks themselves, it can be seen what an advantage a thoroughly distinctive light would become. This light can be seen at the Weymersch battery stand, and has received considerable attention from naval men. It is stated that seamen can tell the alteration of a single spoke of the wheel by the change in the look of the crescent or ring. It is proposed to make all lamps the same standard size, so that the size of the light gives some indication of the distance of the ship.

The other novelty we mentioned as worth attention is a new speed indicator—the "Showspeed"—invented by Mr. James Murdoch Napier, M.I.C.E., and shown by **Messrs. D. Napier and Son**, Vine-street, Lambeth. It is one of the simplest and most accurate and effective speed indicators we remember to have seen. All it consists of is a revolving drum filled with mercury, driven by a strap and worm gearing, the drum having an upright glass tube, in which is placed an ivory

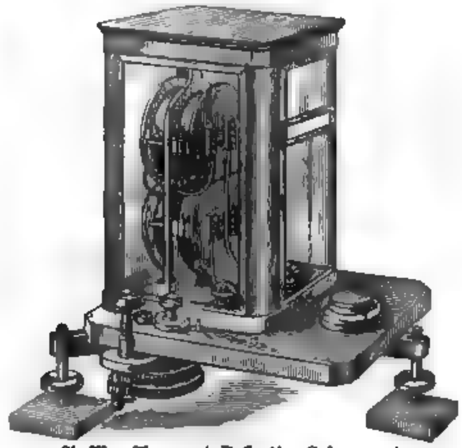
float having a black mark upon it. The rotation by centrifugal action forces the mercury up the tube in proportion to the speed, which is read off on a plainly visible scale attached to the tube. The indicators are constructed for various speeds, from 100 up to 1,000 or more revolutions, and already several of them are in use at the Exhibition for dynamos and engines.

No other exhibitors at the Crystal Palace have, we think, a collection of so many and important exhibits of electrical machinery, plant, instruments, apparatus, and practical applications of electricity generally for light, power, signalling, and all other uses under the sun, as have the world-famous company of **Siemens Bros. and Co., Limited.** We propose in this article to describe and illustrate some of their exhibits more particularly and in detail.

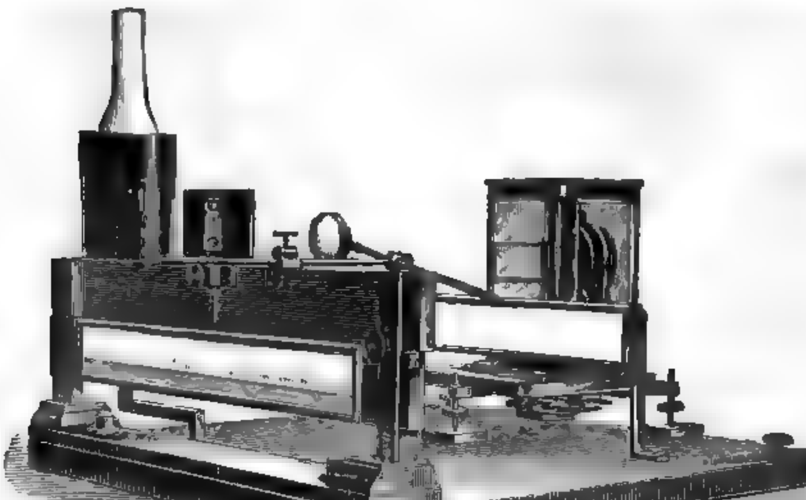
to supply the current at the recent Naval Exhibition, which, as we have mentioned, have been since purchased for the new station of the St. James's and Pall Mall Company at Carnaby-street. We likewise illustrate the well-known Siemens alternator with separate exciter, new types of which are also shown in the Machinery Department. From an historical point of view, there is nothing in the Exhibition likely to be of greater interest to electrical engineers than a small dynamo to be seen on Messrs. Siemens's stand in the Main Transept. This dynamo is within a few days of being a quarter of a century old, and is the first practical dynamo machine ever constructed, being the original machine made by Sir William Siemens, the forerunner of the innumerable progeny that now furnish the world with light and power. This dynamo was used in the Royal



Siemens Alternator.



Sir Wm. Thomson's Reflecting Galvanometer.



Siemens Testing Set.

Sir Wm. Thomson's Reflecting Galvanometer

The large central station dynamo and engine, direct-coupled, embodies the latest and best practice in the manufacture of continuous-current plant for supply of towns or districts. The dynamo is the largest size of the Siemens continuous-current type, with vertical two-pole field magnets, the armature being an immense drum laid rather than wound, with solid copper bars. Running at a comparatively slow speed of 350 revolutions a minute, this dynamo gives an output of 1,600 amperes at 120 volts, capable of supplying about 3,000 lamps of 10 c.p. It is coupled on the same shaft and bed-plate to a Willans and Robinson triple-compound engine, closed type, practically consisting of three separate engines driving upon one shaft, and supplied from the same steam-pipe, having its own steam separator. This central station set was one of several used

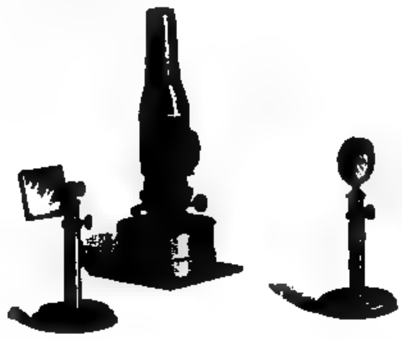
Institution and before the Society of Telegraph Engineers to furnish current for magnetising the large magnet.

In telegraphic and testing instruments Messrs. Siemens have a very fine and extensive show. Of these we illustrate several—the standard testing set, used for testing of all kinds, in the manufacture of cables, the testing of land lines or submarine cables, or electrical testing for resistance and capacity. The principal peculiarity of their instrument is the arrangement of the reflected beam of light from the galvanometer mirror. The lamp is placed beside the scale, its ray is taken by the lens and sent into the galvanometer, reflected from the suspended mirror upon an opal or frosted screen. This has two advantages—first, that the ray has a long distance to travel, and therefore shows delicate readings; and secondly, the spot of

light shows through the frosted screen, and is perfectly easy to observe without the observer's head coming into any awkward position. The constituent parts of this set, consisting of a Thomson reflecting galvanometer, lamp and reflector, lenses, and transparent scale, are shown separately. The telegraph station set of keys and resistances to be used with this galvanometer is also illustrated. This contains a resistance bridge (Siemens pattern), a set of comparison coils, branch coils, battery commutator, key, short-circuit switch, and peg commutators. The connections are permanent, and all necessary changes for testing cables and localising faults are made by simply altering the pegs. The galvanometer used for marine work is more strongly and compactly built and enclosed to stand transport. It is a dead-beat reflecting galvanometer, with tube arranged for liquid damping of the vibrations, as used for telegraphing and testing submarine cables and use on board ship. Two very different types of galvanometers are also shown. Tangent galvanometers (Obach's pattern), small and large size, have movable ring for the absolute measurement of powerful currents and E.M.F.'s; and Siemens's wire torsion electro-dynamometer, for the measurement of very weak currents. In this latter instrument there are two stationary coils (one removable) and a spherical movable coil. This coil is suspended by means of a very fine platinum wire at the top, and a spiral of fine copper wire at the bottom. Telephone currents can be readily measured by this instrument. A very convenient and useful set is that of the Siemens universal galvanometer, furnished with shunt, commutator, wire bridge, and resistance stopper, in mahogany case. It is a compact instrument, much used in ordinary work for taking resistances and finding the position of faults. The ordinary lineman's detector galvanometer used for all and sundry continuity tests, for telegraph or electric light wires, is too well known, even by non technical folk, to need more than mention.

Turning now to measuring instruments more definitely adapted for electric light work we have that most useful instrument, the Siemens standard electro-dyamometer. These are shown in various sizes to measure from 0·2 up to 500 amperes, and in portable form from 2 to 500 amperes. For measuring E.M.F. the potential galvanometer is a convenient and accurate instrument, measuring resistances from 0·01 up to 170 volts, or in larger form 0·01 to 1,700 volts. These are also made in portable form measuring 10 to 150 volts, or 20 to 300 volts. The ordinary Siemens voltmeter and ammeter is very largely used, especially on board ship for electric light plants. These are torsion instruments, read by turning the pointer till the needle is in equilibrium.

Several forms of Siemens's high-tension exploder for fuses and mines are shown, of which we illustrate two.



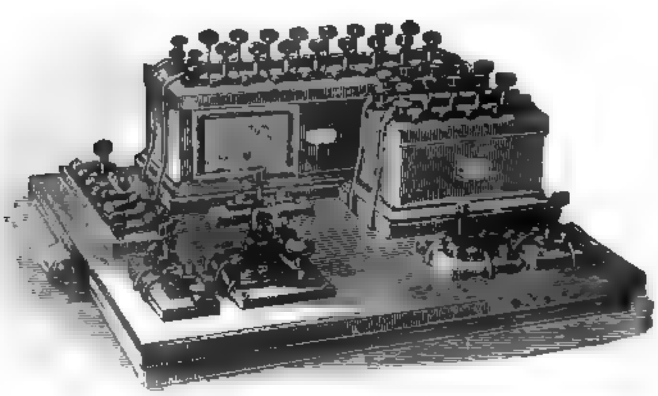
Lamp and Reflector Lenses.

Transparent Scale.

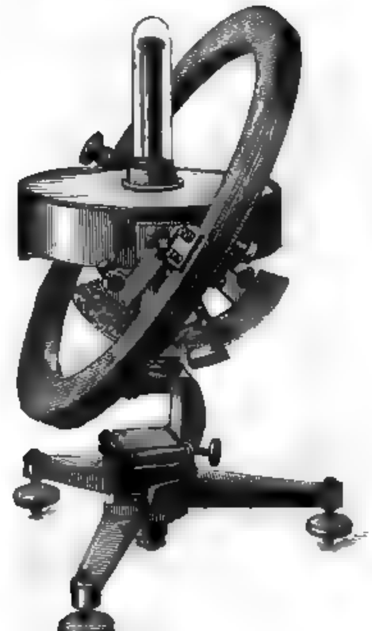
Wire Torsion Galvanometer.

Reflecting Galvanometer for Marine Work.

Tangent Galvanometer.



Telegraph Station Set.

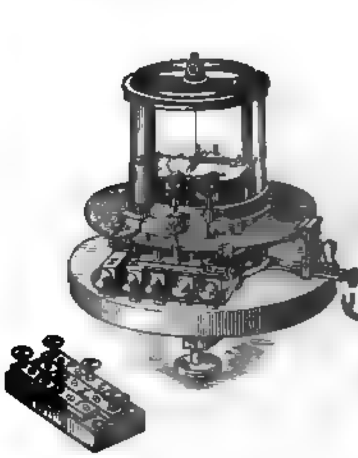


Tangent Galvanometer—Dr. Obach's Pattern.

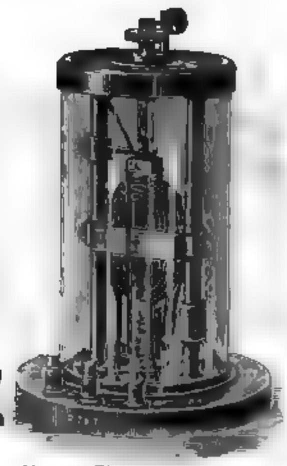
These are in reality small dynamos, giving, with vigorous rotation, 400 or 500 volts, capable of sending a strong spark through 20 or more fuses for simultaneous explosion.

The Hellesen dry cells, which are made and exhibited by Messrs. Siemens, are illustrated, showing the three usual types, and also the arrangement for house use in wall boxes. These batteries have an E.M.F. of 1·5 volt, and their internal resistance low—under 0·5 ohm for types Nos. 1 and 2, and under 1 ohm for No. 3. They can be used for closed as well as open circuit working, and are very constant with high recuperative power. The polarisation is very small, making them specially adapted for telegraphic, telephonic, and domestic service. They are very cheap, and mounted sections of cable is a complete set of the Siemens system of underground mains, both for low-tension and high-tension distribution, with street boxes uncovered to show method of connection—the high-tension connecting-box for concentric cable being specially interesting.

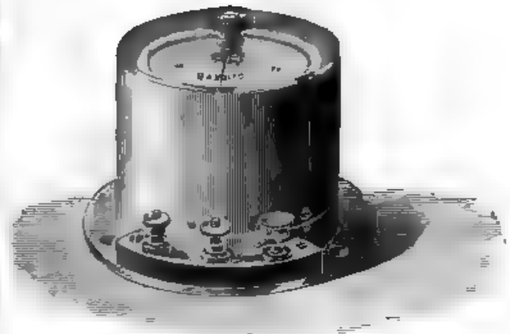
These exhibits are nothing if not practical, and one of the most practical, not being actual plant, will be the "portable testing set" on wheels. This is for the convenient use either of linesmen for street telegraph work, or for cable men laying mains for the electric light. It consists of a kind of covered van on wheels with handles for pulling, with door closing under lock and key, fitted inside with all the materials and instruments for careful testing.



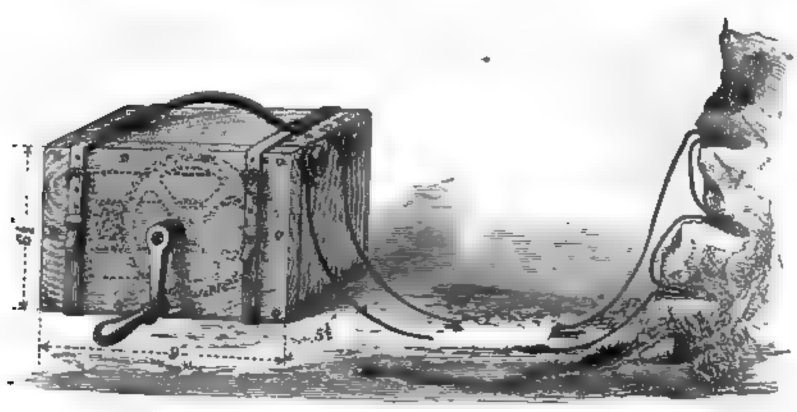
Universal Galvanometer and Shunt Box.



Siemens Electro Dynamometer.



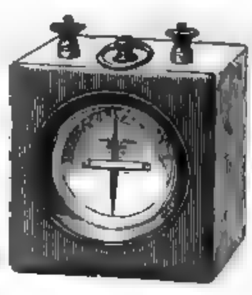
Siemens Voltmeter—Marine Type.



Siemens High-Tension Exploder.

Potential Galvanometer.

Siemens Exploder with Cover Off.



Detector.

Resistance for Potential Galvanometer

give a large current for a considerable time, while being without liquid, are very clean and portable. For military field work, medical apparatus, and firing batteries they are much used. For household and hotel work they are fitted in wooden wall boxes to hold two or more cells.

At Messrs. Siemens's stand, besides the numerous instruments we have specially mentioned, are others well worth the attention of electrical engineers, to which we must do greater justice later. Two fine cases of cables show a large variety of telegraph, submarine, telephone, and electric light cables. Among these are specimens of the iron-sheathed concentric cables used on the London Electric circuits. But of more practical aspect than Three legs drop down to the ground and form a firm base for a reflecting galvanometer; a battery of 100 cells is stowed away at the back, and keys and resistances are conveniently arranged. The whole front is covered with a tarpaulin. The tester lets down a seat, lights his lamp, draws the curtain around him, and tests his mains. When finished he rapidly disconnects, packs up, and wheels his "testing van" to the next place of juncture.

Further practical articles are shown on the table for use of high-tension men. These consist of tools with handles covered with ebonite. Screwdrivers have their ordinary wooden handles covered ¼in. thick with ebonite; pliers the same beautifully covered with ebonite coating, and

safe to the hands of the worker. Chisels for cutting copper, and even spanners for unscrewing junction-pieces, are likewise coated with a thick covering of smooth and polished ebonite direct upon the metal. These tools should be found absolutely necessary where interference with live wires is required for station work.

In arc lamps Messrs. Siemens show fine specimens of projectors, not to mention an immense variety of lamp carbons.

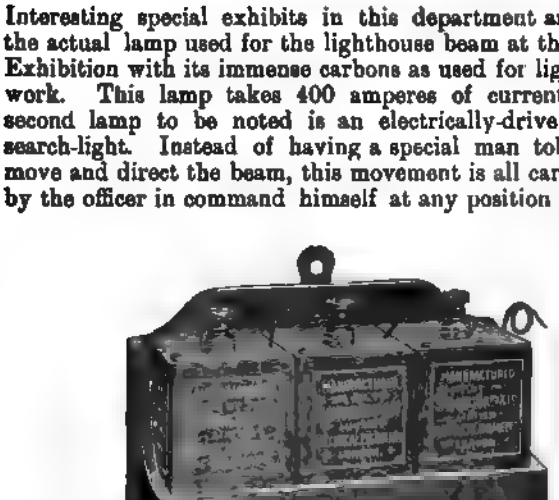
GIANT'S CAUSEWAY ELECTRIC RAILWAY CO.

The sixteenth yearly meeting of this Company was held at the Company's offices, Portrush, on Monday, Dr. Anthony Traill presiding.

The **Chairman** submitted the Directors' report for the year as follows: Your Directors beg to submit, for the approval of the shareholders, their annual report to December 31st, 1891, which completes the ninth year since the line was opened for traffic.

Hellesen's Dry Cells.

Interesting special exhibits in this department are, first, the actual lamp used for the lighthouse beam at the Naval Exhibition with its immense carbons as used for lighthouse work. This lamp takes 400 amperes of current. The second lamp to be noted is an electrically-driven ship's search-light. Instead of having a special man told off to move and direct the beam, this movement is all carried out by the officer in command himself at any position desired.



Hellesen's Dry Cells in Wall Box

The motion is brought about by magnets or motors, controlled by an ingenious switch, termed "bi-planer switch," the handle of which can move over contacts, up and down, or from side to side at the same time. The contacts control the light and movement of the projector entirely by slight movements of this one switch.

We have not yet exhausted the exhibits at Messrs. Siemens's stands; there is still their automatic electric block train signals; automatic defence mine exploders, besides the intricacies of the model electrically-lighted theatre in the Pompeian Court; demonstrations of the telephonic curves in the interior of the telephone; the experiments with the high-tension currents of 50,000 volts by means of their "electric sea-serpent," or cable shaped transformer, and the 50,000-volt transformer, which will be exhibited to the public after this week. Few exhibitors have taken such trouble to interest both the general public and electrical engineers, and their stands will certainly be one of the great attractions of the Crystal Palace Exhibition.

Your Directors are glad to be able to report another large increase in the passenger traffic in the year, the first-class passengers having increased to 9,292 from 8,943 last year, and 7,845 in 1889; and the third-class passengers having increased to 82,406 from 73,859 last year, and 56,822 in 1889—the total for the year being 91,698, with corresponding receipts, amounting to £2,830. 4s. 2d., as against a total of 82,802, with receipts £2,579. 19s. 5d. in 1890, and a total of £64,669, with receipts £2,338. 11s. 7d. in 1889. The goods and mineral traffic amounted to 181 tons, compared with 316 tons in 1890, and the receipts have been respectively £29. 1s. 5d. and £41. 8s. 11d. The receipts for parcels and miscellaneous traffic have diminished during the year from £77. 7s. to £19. 19s., so that the total receipts from the revenue account have been £2,895. 14s. 7d., as against a total of £2,698. 15s. 4d. in 1890. There has, however, been considerable increase on the expenditure side of the account, which shows a total of £1,945. 6s. 6d., as against £1,687. 12s. in 1890, and £1,732. 10s. 9d. in 1889. There is consequently a credit balance on the result of the year's working of £950. 8s. 1d., as against £1,011. 3s. 4d. in 1890, and £381. 18s. 7d. in 1889. This result has again fulfilled the anticipations of the Directors, and is traceable not only to the increase in the passenger traffic, but to the alteration made three years ago in the arrangements with regard to the goods traffic, which had previously been a constant source of loss to the revenue. It will be seen, on an examination of the above figures, that the ratio of expenses to receipts, which was 82 per cent. in 1889, and 62 per cent. in 1890, has been 67 per cent. in the past year. The value of electricity as a locomotive power, when generated by water power, as compared with steam, continues to be shown remarkably. The expenses of the electrical working amounted to £314 for 19,863 miles run, or less than 4d. per mile, while steam power cost £635 for 12,280 miles run, or 1s. 0½d. per mile. Your Directors regret the considerable increase in expenditure during the year, but they have found it necessary to refence the line for almost its entire length, to prevent accidents to cattle. They have also paid for the conversion of three waggons into cars out of revenue, and have spent a considerable sum in the renewal of the electrical apparatus, and, as the permanent way and steam engines have been kept in complete order, everything will be found in proper condition for the ensuing season. Your Directors regret that they are not yet in a position to offer a dividend to the shareholders, nor can they do so until the net revenue account is brought into a more favourable position; but they think it is evident from the great improvement which has taken place in the finances of the Company during the last two years, that the time is approaching when they will be able to do so; and they have to offer their thanks to their various supporters for their long-continued forbearance during trying times, not only for the Company, but for the country at large. The rapid increase in Portrush from year to year is most favourable to the prospects of the Company, as that town provides a constant stream of visitors to the Giant's Causeway and the intervening coast scenery; while tourists from distant parts, and the artisans from the manufacturing towns of Ulster, will add a large contingent, so long as the country generally is prosperous, and agitation is crushed out by firm government. Mr. Stuart and Mr. W. A. Traill are the directors who retire by rotation, and they are eligible for re-election.

Mr. Henry proposed, and **Mr. Stuart** seconded, the adoption of the report, which was passed.

Mr. C. M'D. Stuart and Mr. W. A. Traill, C.E., the two retiring directors, were re-elected.

THE

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CONTENTS.

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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NOTICE.

With this issue of the Paper is given a Supplement containing Portraits, taken from photographs, of **Mr. W. B. Esson, Sir Benjamin Baker, Mr. G. Binswanger, Mr. G. A. Grindle,** and **Mr. R. W. Wallace.**

Every reader should see that he gets this Supplement, and non-delivery with the Paper should be reported at the Publishing Office.

TESLA.

Although Prof. Ayrton in his presidential address has raised many points suitable for discussion, and although many questions of a practical character arise out of the meetings of the City and South London and the Central London Railway Companies, not to speak of those concerning the exhibition at the Crystal Palace, it is inevitable that we give the place of honour to our guest from across the Atlantic. Till a short time ago, Tesla was a name almost unknown to English ears. A few men had watched the announcements of his work in America, and Prof. S. P. Thompson, if we remember aright, introduced the name of the worker and his work in the borderland of science to the English public. But the man himself is now amongst us, and after his brilliant experimental lecture in the theatre of the Royal Institution on Wednesday the name will become as familiar as a household word. Geissler tubes have long been shown in the laboratory and the lecture-room, and many men have thought that in the dim and distant future something practical might arise from that root. De la Rue made many investigations; Spottiswoode, as will be remembered from his paper at the York meeting of the British Association, carried on the work; but perhaps above all others Crookes delved most deeply into this borderland of science. Now we have Mr. Tesla going many steps beyond his predecessors, mainly because he has called to his aid far greater "frequencies." The field of investigation has other explorers in Lodge, Hertz, J. J. Thomson, and we believe that the work done by Willoughby Smith ought not to be lost to view.

It was an excellent suggestion of the Institution to obtain the consent of the Royal Institution so that Mr. Tesla might expound his discoveries and show his experiments upon the spot which the immortal Faraday has made sacred to science. Hence it was that on Wednesday a brilliant gathering of members of the Institution met in the historic theatre to listen to the most recent and most wonderful discoveries in electrical science, and to witness experiments which to many of the audience undoubtedly came as one of the greatest surprises of the century. Mr. Tesla commenced his lecture by acknowledging his great indebtedness to Prof. Crookes, whose work first led him to undertake investigation into what at first sight seems a field rather barren of practical results. Perhaps, however, we are sometimes too anxious to see the end before the beginning is rightly grasped; still, we agree with those who consider blind experiment a waste of time. That is, the experimenter who, Micawber like, waits to see what will turn up, cannot be placed upon an equality with the one who has an object to gain and an end in view. It would be futile to attempt to describe Mr. Tesla's lecture or to discuss his investigations. That can only be done in a lengthy illustrated article, which no doubt will be duly forthcoming. It was perfectly evident, however, that Mr. Tesla's object is to obtain light, to supersede the present form of incandescent lamp by another form, to supersede the existing dynamo by another type. This is a very definite object, one that

G. BINSWANGER.

SIR BENJAMIN BAKER.

W. B. ESSON.

R. W. WALLACE.

G. A. GRINDLE.

deserves success, and one which, if it succeeds, will create a revolution in the industry. The scientific questions involved are of great interest, and will no doubt receive careful attention. Mr. Tesla kept his audience spellbound for two hours, and at the end of that time explained he had only performed about one-third of the experiments he wished to show. We trust that after all these years during which, as the lecturer said, the apparatus used has been common property, some practical development will be found to prove its utility.

CANTOR LECTURE—No. 2.

Prof. G. Forbes, in his second Cantor lecture on Monday last, discussed a number of interesting problems connected with distribution. Early in the lecture he referred to the term load factor introduced by Mr. Crompton, and stated that the definition of the term was indefinite. Mr. Crompton had made five distinct references, but Prof. Forbes would reduce the use of the term to three cases: (1) the machinery load factor; (2) the current load factor; and (3) the temporary load factor. It seems to us that (2) and (3) resolve themselves into one. The definitions given by Prof. Forbes are: (1) the ratio of the average current to the maximum current the machinery is capable of supplying, or

$$\frac{\text{average current}}{\text{maximum current of machinery}};$$

Similarly (2) is

$$\frac{\text{average current for period under consideration}}{\text{total current used in period}};$$

and (3) is

$$\frac{\text{average current for temporary period}}{\text{maximum current for that period used}}.$$

A brief review of the use of the multiple series method of distribution as in use at Temesvar and the Secteur Clichy in Paris, brought the lecturer to the important subject of alternate currents and transformers. A fairly exhaustive consideration was given to the use of transformers in each house and in sub-stations; the lecturer concluding with a description of some of the principal systems of mains in use.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

CRYSTAL PALACE EXHIBITION.

SIR,—We have been looking anxiously for some specimens of electric welding apparatus in the exhibition in the Crystal Palace, but there are no signs thereof at present. We miss also the Parsons steam turbine. Is static electricity quite forgotten? A good influence machine shown in operation would be a great attraction. Those who can remember the beautiful machines in the Polytechnic in Regent-street will know what wonderful effects were produced from them. W.

THE ELECTROLYTIC LAW OF LEAST ENERGY.

SIR,—By the accidental omission of the words "the lowest," my letter, page 109, has become unmeaning. The extract should read:

"*At the electrode those ions are set free which absorb, in becoming free*, the lowest specific energy.—Yours, etc.,

J. T. SPRAGUE.

LITERATURE.

Electric Light Cables and the Distribution of Electricity. By STUART A. RUSSELL. With 107 illustrations. Whittaker and Co., London.

We have considerable pleasure in recommending to the notice of our readers Mr. Stuart Russell's book on "Electric Light Cables," which forms the latest addition to the "Specialists' Series," published by Messrs. Whittaker and Co.

Within the moderate compass of some 300 pages a large amount of useful information is contained; and although the treatment of conductors in regard to the *design* of a system of mains for any practical case can hardly be said to be complete, this little book should prove valuable to those electrical engineers who have not had experience in this branch of practical work.

After some introductory and historical remarks, Mr. Russell discusses the relative advantages of different materials for use as conductors of electricity, and he arrives at the conclusion, already well known in practice, that copper—soft or hard-drawn—and silicon-bronze are really the only materials suitable for practical work at the present time.

The relatively great cost of the insulation as compared with that of the conductor makes conductivity of supreme importance in the case of continuously insulated cables, but for bare overhead conductors the values of different materials may be fairly compared by tabulating the values of $\frac{\text{conductivity} \times \text{breaking stress}}{\text{specific gravity} \times \text{cost per ton}}$.

The question of economy in conductors next occupies Mr. Russell's attention, and he proceeds to discuss the particular case in which either a constant current or a variable current with a nearly constant pressure at the consumer's premises is employed. For this case Sir William Thomson gave the solution in 1881, and Mr. Russell shows how the solution is arrived at, and discusses the points which have to be taken into consideration when employing it in practice. He concludes the consideration of the economical aspect of design by a reprint of the tables given by Prof. Forbes in his Cantor lectures in 1885, and he very properly points out that the rise of temperature of the conductor and the loss of pressure in it must be carefully taken into account, and that these two considerations may make it advisable sometimes to use a smaller current density than that dictated by economy.

Mr. Russell gives a short account of Mr. Kennelly's experiments on the heating of conductors, and some useful tables based upon the results obtained.

After referring to the difference in the value of the ratio $\frac{\text{maximum current}}{\text{average current}}$ for direct and alternating currents, and to the bearing of this on the question of economy; and after printing Mr. Mordey's table of the virtual resistance of conductors for alternating currents with different frequencies, Mr. Russell proceeds to describe and discuss systems of distribution, with reference to the cost of the mains, and the greatest distances to which electric energy can be supplied from a central station.

Some very interesting chapters then follow on the construction and jointing of different forms of conductors, on the insulating materials employed, and on the considerations which determine the thickness of insulation in different cases, on lead-covered cables, on junction and terminal boxes, etc.

The important subject of testing of cables for conductivity, insulation, and mechanical strength is next dealt with, and the conditions under which such tests should be carried out to make them of any real value carefully described, and descriptions of the ordinary methods employed in practical testing are given.

A chapter on internal wiring next follows, in which Mr. Russell deals pretty fully with the prevention of fire risks, permissible loss of pressure in house wiring, and with practical methods of wiring and fitting an installation in a safe and durable manner.

We come then to overhead lines, with a discussion on their supports, insulators, lightning protectors, and on the calculation of the stresses in the lines and bearer wires.

We thoroughly agree with Mr. Russell that the Board of Trade rule, which insists on a factor of safety 6 for a wind pressure of 50lb. to the square foot, is altogether unnecessary, and we doubt whether there is an overhead line in the world conforming to this (in our opinion) absurd rule.

The remainder of the book is occupied with descriptions of various systems of laying underground mains and of the conduits for carrying them. The principal systems in use are clearly described and well illustrated, and form an interesting account of the present methods of putting down underground mains.

While we think Mr. Russell's book both a useful and interesting one, we must point out one or two points in which we think he is in error, and which we hope to see amended in future editions. To take the most important first, we are distinctly at issue with Mr. Russell when he decides that the cost of the energy wasted in conductors should not include an amount for interest and depreciation on plant. Loss of pressure and waste of energy cannot be considered separately in the way Mr. Russell apparently does. He says, on page 20, "In the design of a station, when the number of dynamos has been decided upon, it is usual to make them of such capacity that they can together supply current for the maximum demand plus an allowance for reserve, and that each can supply its current at such a pressure as will provide for the loss in the longest feeders which can be required in the district, and then to provide means for reducing the pressure as required by lowering the speed or adjusting the field strength. . . . This being so, it is evident that as long as no mistake has been made in the estimate of the maximum pressure required at any station, the first cost of the dynamo and machines is not affected by a variation in the amount of energy wasted in the conductors."

Now, if the dynamos are required to give a higher pressure than is required at the consumers', it means, of course, that their output and that of the rest of the plant is greater, on account of the resistance of the mains, in the ratio of the pressure at the station to that at the consumers', than it would be if the conductors were of such size that their resistance was negligible.

The extra output is directly necessitated by the fact that the conductors are of a particular size, and the interest and depreciation on the extra amount of plant required should be debited along with the cost of the energy wasted in the conductors, when we seek to proportion the conductors for maximum economy or minimum total expenditure per annum.

On page 51, Mr. Russell says that in the series system the speed of the engines and dynamos is reduced with the load, so that the work done per stroke is kept constant. In the Brush and Thomson-Houston systems, which operate the great majority of arc lamps in the world, it is customary to employ automatic regulators, which shunt the field magnets or move the brushes on the commutator, and we think that regulation by means of the governor (whether by hand or automatic arrangement) is but comparatively seldom used.

We notice that, while Mr. Russell uses the notation of the differential calculus (on pages 18, 19, 20, for example), he prefers lengthy expressions and reasoning to using the notation of the integral calculus. On page 24, for example, in place of the expression for the square root of the mean square of the current, we think he might write

$$C = \sqrt{\left\{\frac{1}{T}\int C^2\, d\, t\right\}}$$

with advantage, or as Dr. Rasch has done

$$C = C_{max}\ \sqrt{\left\{\frac{1}{T}\int i^2\, d\, t\right\}}$$

where C_{max} = max. current of the year considered.

$$i = \frac{\text{current at any instant}}{C_{max}}$$

Again, on pages 107, 108, and 109 we think

$$R = \frac{s}{2\pi l}\int_d^D \frac{d\,r}{r} = \frac{s}{2\pi l}\log_e \frac{D}{d} = \frac{s}{2{\cdot}728\, l}\log\frac{D}{d}$$

very much simpler than performing the integration by summing the series as Mr. Russell does; and the engineers who know that

$$\left(1 + \frac{1}{x}\right)^x = e \text{ when } x = \infty$$

know also that $\int \frac{d\,r}{r} = \log_e r$, while those who have to take on trust the value of e, may just as well be given the value of the integral at once.

At various parts of his book Mr. Russell writes

$$R = R_0 \times 1{\cdot}0021^t$$

when R = resistance of copper conductor at t deg. F.
R_0 = resistance of copper conductor at 0deg. F.

and we think the simpler, and as we believe more accurate, formula

$$R = R_0\,(1 + 0{\cdot}0021t)$$

would have been employed with advantage. We may point out that Matthiessen's results do not bear out Mr. Russell's formula so well as the simple one. Matthiessen's results were given by the formula

$$R = \frac{R_0}{1 - a\,t + b\,t^2},$$

which gives a curve of R and t at first concave towards the R axis, but at a quite low temperature there is a point of inflection, and the curve bends over and is concave towards the axis of t.

NOTES ON THE MANAGEMENT OF GAS ENGINES.

(Extract from "First Principles of Electric Lighting.")

The following notes are mainly intended for those who, although not mechanics or engineers, may find themselves in charge of a gas engine—a source of power the use of which is extending by leaps and bounds. The management of these engines is really a simple matter; at the same time, they will not run without some little care and attention. The writer has had many years' experience in the management of gas engines, and it is hoped that these notes will be of assistance to those for whom they are written.

Although many of these notes are applicable to various makes of gas engines, they especially refer to Crossley's "Otto" (slide-valve type) and the new Crossley "Otto," hot-tube ignition (without slide-valves), each being dealt with separately.

Starting.—See that everything is *clean* both inside and outside, that the water is properly supplied to the cylinder jacket, and that the moving parts are free and well oiled; then light the burner at bottom of chimney and adjust the inner light, which should be turned as high as possible without causing it to smoke.

Next move the governor to its middle position, and keep it there by means of the "stop" provided for this purpose, so that it can act on the gas-valve. The "stop" should disengage itself as soon as the engine begins to run.

How to Turn the Flywheel Easily.—To facilitate turning the engine by hand at starting, the roller on the exhaust valve lever may be moved further out so as to engage the *second* cam (or projection) on the shaft, the pin that secures it being changed to the other side of the roller for the moment, but when the engine has started *the roller must be replaced and secured* again so as to be moved by one cam (or projection) only as before.

In the vertical type of engines the exhaust roller is lifted *upwards*, and held there by the taper pin whilst starting; when started, the pin is pulled out and the roller drops into its working position and requires no securing. In the smaller sizes of engines no relief cam is required.

Quantity of Gas at Starting.—To prevent *too much gas* being given while turning by hand at starting (which often prevents ignition), close the tap *behind the bag* until the engine begins to work; if the bag be emptied before the engine has started, gas must be again admitted to fill the bag and another attempt made. After a short time a

position may be found in which to place the tap so as to admit the gas slowly, turning it *full on* as soon as the engine is fairly started.

Some engines being troublesome to start from this cause, a small by-pass tap (the main tap being closed) will be found very convenient in starting, or a gas pressure regulator can be fitted between bag and gas main. These matters being attended to, open the engine gas tap, turn the flywheel as quickly as possible a few times by hand, when the engine will at once begin to work. *It is useless pulling the engine slowly round.* It only wastes strength and fails to start the engine.

Difficulties in Starting.—If the engine should take long to start without apparent reason, examine the exhaust-valve, and ascertain whether any dirt or other cause prevents it closing tightly. If this valve is not at fault, look to the *gas supplies* at every point.

Sometimes water, by accumulating in the exhaust-pipe, may cause stoppage. A small hole or a tap at the lowest point of the pipe will prevent this.

If all attempts at starting the engine fail, do not tinker with it, but *get a man from the makers* to attend to it, carefully noting what he does and asking him to explain the cause of the difficulty, but if ordinary care be taken, and these instructions carefully followed, no serious difficulty is likely to occur.

Lubrication.—The two principal parts requiring lubrication are the slide-valve and the piston. Self-acting oilers are provided for both. These should deliver from four to twelve drops a minute to the cylinder, according to size of engine, and two to the slide-valve. See that they drop the oil as intended, as if allowed to run dry the surfaces will "cut" and the slide-valve will require to be "faced," or the duplicate valve, etc., put on before the engine will work again. The interior of the cylinder may also be seriously damaged.

Oil all the other bearings three or four times a day in the usual way, and see that none get too warm by being too tight or too dry.

Oil.—It is advisable to use oil supplied by the engine-makers. The price is rather higher, but it is worth it, and inferior oils always lead to difficulty from dirt left in the cylinder and ports, causing irregular working and sometimes a total stoppage. *The quality of the oil is a most important matter.*

Regularity of Ignitions.—Always see that an ignition occurs *each* time the small gas-valve is opened by the governor. If it does not, the cause may be dirt in the slide-ports, or want of regulation of the slide lights, or wear of slide-valve. The gear which opens the gas-valve may also, after a time, wear a little, and thus decrease the supply, causing loss of power or stoppage. If so, it is easily adjusted.

Water Vessel and Cooling.—Never work the engine without water in the jacket of the cylinder. The water vessel must be kept full by a ball tap.

See that the circulating pipes are acting. The pipe from top of cylinder to water vessel should slope upwards at every point, being nowhere exactly horizontal or sloping down. The cylinder should not get very much hotter than the upper part of water vessel. If the engine is exposed to frost when not working, burn a gas light under the cylinder, *to keep the water from freezing*, or if more convenient the cylinder may be emptied. Neglect of these precautions may cause the bursting of the cylinder jacket owing to ice forming.

Exhaust-pipe.—Never turn the exhaust-pipe into a flue, chimney, or drain, lest an accumulation of gas may accidentally take place and damage be done. Lead it to the open air, keeping it clear of all woodwork by 6in. or 10in., as it gets very hot when in use.

Cleaning Slide-valve.—Remove the slide-cover, take out the slide-valve, and clean all the passages in the various parts, especially the small hole in the slide-valve *leading from one* of the square ports to the small hole through valve just above the port. This hole, not being visible, often escapes attention. The small hole in back plate leading into cylinder also requires thorough cleaning to its full depth. After cleaning and freeing all the parts from grit, oil the surfaces thoroughly and replace the slide and cover, which must be adjusted as follows: Place the split stops on screw studs, then the springs and milled nuts, tighten up the springs by means of the milled nuts, move the engine round a few turns by hand, then tighten up the small nuts on the split stops with the short spanner provided for the purpose, and having afterwards slackened the milled nuts the slide will be ready. Small tools for cleaning are sent with each engine.

Changing Slides. — Difficulty in starting will occur after a time from slight wear of the surfaces of the slide-valve, or from injury from want of oiling. When this occurs the best plan is to send the whole set—viz., back plate, slide, and slide-cover—to the makers, as they will then be properly faced up, an operation requiring considerable skill and practice.

In the meantime the spare set of slides must be brought into use, taking care to clean out the tallow and white lead, not omitting the small hole mentioned in "Cleaning Slide-valve." The gas fittings must be carefully removed from the damaged set, and placed in the spare set. When placing the back plate on cylinder end, see that no dust or grit is on the surfaces, or the screws will not draw them into close contact, and a "blow-by" will result. See also that the screw-driver used raises no "burr" on the screwheads which might project above the surface of back plate; the slide-valve and cover are placed in position as described in "Cleaning Slide-valve."

The Piston.—The piston should not be taken out unless cleaning or new packing rings are needed. When it is taken out, scrape everything thoroughly out that may be left at the back of cylinder, but if the oil and gas are good nothing will be found. The crank-pin brass has alone to be uncoupled to draw the piston.

If it be necessary to fit new rings owing to an escape by the piston, only change one ring at a time, commencing at the back. The joints of all the rings should be at the bottom side of the piston. To draw the piston is easy, to put it back, turn it upside down, and when in the cylinder turn it round so as to bring the figures on connecting-rod to the top. Be careful to see that the small steady-pins in piston ring grooves fit into the slots in the rings, or the rings will get broken.

It requires some practice to readily replace the piston, and unless really necessary it should not be withdrawn when doing it, have patience, and do not use force.

In 16-h.p. engines the cylinder should be cleaned out inside once a week, *not by removing piston*, but by scraping the dirt out through the cover over exhaust-valve, which is made large enough to admit a youth's arm.

The Governor.—The governor performs two distinct functions—it cuts off the gas both when the proper speed is exceeded and when the engine stops. See that these are properly performed, and that the gas-valve shuts correctly, lest running away or waste of gas accidently follow.

The Gas-valve.—This only requires a little "grinding in" at long intervals. See that the stem is clean and free from stickiness, and that the spring causes the valve to close sharply.

The Air-valve.—This again requires little attention, and the remarks *re* gas-valve apply equally to this.

The Exhaust-valve.—This valve requires close attention if the engine is to work regularly and efficiently, it being exposed to intense heat and to the cutting and corrosive action of the exhaust vapour. If this valve does not close tightly, not only is there a large waste of gas into the exhaust-pipe, causing annoying explosions in the same, but the remainder of the mixture of gas and air is not properly compressed, causing great loss of power when exploded, and often missing exploding altogether, so causing further waste.

To test the condition of this valve (although it often makes itself known by a difficulty in starting the engine), turn the engine by hand without moving the exhaust-valve roller from its normal or working position. If the valve be in good condition, great resistance will be felt on the in-stroke of the piston during which the compression takes place, and if the flywheel be suddenly released, the engine

will make one or two revolutions backwards, owing to the reaction of the compressed air. If, however, the valve be leaking, the air can be heard "blowing through" it, and little or no resistance experienced in turning the engine by hand.

Owing to the neglect of this valve, from want of knowledge, a considerable amount of gas as well as power is lost by most gas engines, and is the cause of the gradual increase of the gas bills, although the work remains practically the same. To repair the exhaust-valve, remove the cover and also the connections at end of spindle, lift up the valve and smear the seat with a little emery and oil, and grind in by giving the valve a circular motion. To facilitate this operation, use a piece of iron rod screwed at one end to fit hole in valve head and squared at the other to fit an ordinary brace or stock; continue the operation until the edge of valve and valve seating show that the parts come into contact all round. When this is the case, wipe off, replace the valve and attachments, put on the cover, and screw down securely, first placing a little black-lead and oil on the threads of nuts and bolts, as the heat is apt to make the nuts "set fast."

Adjustment of Exhaust-valve Lever.—There should be nearly ⅛in. play between the roller on exhaust-valve lever and the body of the cam *when not lifting*, to ensure the shutting of the exhaust-valve. The operation of grinding in (above mentioned) tends to lower the valve, and so reduce this distance.

Protection from Dust.—Keep the engine clean and free from dust and dirt, taking particular care that none can fall on to the slide from roof or ceiling.

THE BERLIN UNDERGROUND ELECTRIC RAILWAY.

The Electricitäts Gesellschaft of Berlin, says the *Eisenbahnzeitung*, is not the only company which has applied for a concession for an underground electric railway in the German capital; but it is the company which seems to have the best chance of obtaining the same. The scheme for such a railway in Berlin has been accelerated by the success of the underground electric railway in London. The company named proposes to construct two lines crossing each other at right angles, and following the main traffic of the city. These two lines would divide the town into four quarters, which would again be connected by two concentric lines, with stations at the points of crossing. The main line, N.-S. (Friedrichs Strasse section), under the Chaussée, Friedrichs, and Belle-Alliance Strasse; and the E.-W. line (Leipziger Strasse section), below Landsberger, Konigs, Leipziger, and Potsdam Strasse. The crossing point of the two tunnels is situated at the cutting of Friedrichs and Leipziger Strasse. If from this point two circular lines, 6,000ft. and 12,000ft. apart, be drawn, we have the course of the two circular lines, but the outer one must be considered one for the future. On the other hand, the remaining lines are to be completed in two years. The lines will be distinctly separated, as the tunnels lie above each other. At the terminal points the metals would run into a loop, so that the train, without actual shifting, will run from one tunnel into the parallel one in the opposite direction. Thus there can be no collision of trains running in opposite directions.

The method adopted by Mr. Greathead in the construction of the City and South London line will be followed, iron tubes being used, whereby the tunnels will be impervious to their greatest enemy—ground water. For the tunnels, oval cast-iron tubes are to be used ⅛in. in thickness, 11ft. high and 9·6ft. wide at the bottom, and which will lie at a depth of from 20ft. to 45ft., or about 6ft. below the bottom of the River Spree. Each train will be composed of three cars, like the ordinary tramcars, having two pairs of wheels at each end, and being open from end to end, and affording seats for 40 persons. The train will be drawn by an engine, an electric locomotive of simple construction, as it will not generate but only utilise the electrical energy. The engines are to be equipped with slow-speed electro-motors, and the necessary brake and regulation apparatus and afford room for the driver and assistant. The trains are to be run every three minutes with a speed under 16 miles an hour. The difficult problem of platforms has been happily solved by placing them in the space between the two parallel tubes, about 30ft. apart. These platforms will be composed of several iron tubes, and access will be gained from the street by elevators or steps, with waiting-rooms above. The lifts will hold 50 persons. At the crossing stations there will, of course, be two platforms, one above the other, and communicating. For the section to be built first, the Friedrichs Strasse line, 14 stopping places are contemplated, and with the speed indicated, and allowing for stoppages, the journey would occupy 20 minutes. The total length in both directions would be about 13 kiloms. (8 miles), and the cost is estimated at £600,000.

MODERN APPLICATIONS OF ELECTRICITY TO METALLURGY.*

BY G. C. V. HOLMES, SEC.I.N.A.

(*Continued from page 94*).

It has been stated that in practice the difference of potential between the terminals of any one tank is between one-half and one-quarter of a volt. Taking, however, the figure of two-thirds of a volt as a standard, and briefly examining the cost of producing the current, at a consumption of 2·24lb. of coal per indicated horse-power per hour, one ton of coal should give exactly 1,000 i.h.p. for an hour. Assuming the combined efficiency of engine and dynamo to be 75 per cent., a figure well within the limits of the best practice, the above engine power should give us 750 e.h.p. or 750 × 746 = 559,500—watt hours. Supposing, for the sake of simplicity, that the whole of the work is done in one huge tank, the conditions of which allow the current to be passed through with a difference of potential of two-thirds of a volt. There would then be a current of 559,500 × $\frac{3}{2}$ = 839,250 amperes for an hour. Now, referring to Table I., a current of one ampere for a second can deposit 0·0003307 grammes of copper; therefore the amount deposited by the same rate of current in an hour = 0·0003307 × 3,600 = 1·19052 grammes, and therefore the current of 839,250 ampere-hours can deposit 839,250 × 1·19052 = 999,140 grammes, or almost exactly one ton of copper can be deposited with the consumption of one ton of coal under the assumed conditions. Of course, for the purposes of the calculation it would have done equally well to have taken the conditions which obtain in the actual process—namely, a much higher E.M.F. and a correspondingly reduced current, so long as we kept the product of amperes and volts constant.

Thus, if an E.M.F. of 100 volts had been selected, a corresponding current of 5,595 ampere-hours would have been taken, and while the copper deposited in each tank would have been $\frac{1}{150}$th of what it was in the first case, the E.M.F. would be sufficient to pass the current through 100 × $\frac{3}{2}$ = 150 tanks instead of one. It need hardly be mentioned here that these figures are only given as an illustration, for in working much smaller currents are dealt with.

To the cost of fuel necessary for producing the current has to be added that of labour, maintenance, stores, and that of refining copper matter, or rough copper, up to the standard pitch of purity, and also that of casting the anodes. The actual cost of producing a ton of pure electrolytic copper varies also somewhat with the design of the plant and the care that is spent in maintaining it. If the current be allowed to run to earth, if conductors of scant area, and if dirty contacts are used, if the electrolyte be not maintained in proper condition, if very impure anodes are employed, and if the current passed through the tanks be so dense that a high E.M.F. is necessary, the cost of electro-refining copper may easily be made ruinously expensive. But if the conditions are made and maintained favourable, as they can be with moderate care, the cost should not exceed from £3. 10s. to £4 per ton, and has in some instances worked out much lower. If due care be exercised in the selection of the brand of copper to be refined, this cost may easily be more than covered by the value of the gold and silver recovered from the sludge in the bottom of the tanks.

Treatment for Rendering the Deposited Copper Suitable for General Use.—The copper deposited in electrolytic refineries, though chemically pure, is of a crystalline character, and possesses but little cohesive strength. It is therefore, in its deposited condition, quite unsuitable for the manufacture of goods, and is, in fact, only used for the manufacture of high conductivity wire for electric purposes, and before being drawn into wire it has to be melted, cast into ingots, forged, rolled,

* Paper read before the Junior Engineering Society, Jan. 15.

and cut into strips. If the copper could be deposited in a tough, dense, and reguline condition at the same time that it was being refined, a great saving of expense would result.

The Elmore Process of Copper Deposition.—Numerous experiments were carried out from time to time with the object of attaining the desired end, but none of them resulted in anything like practical success until Messrs. Elmore invented the beautifully simple process of continuously burnishing the copper while it was being deposited, without removing the cathode from the bath.

The manner in which this is done may be described as follows: A mandrel of iron, or preferably of copper, is mounted on insulated bearings in the tank or bath, and a burnisher consisting of a small prism of agate is caused to travel, like the cutting tool in a lathe, along the surface of the mandrel in a direction parallel to its axis. While the current is passing, the mandrel is caused to revolve by wheel and chain gearing. The anodes are arranged at the sides and bottom of the mandrel, and as near the latter as can be conveniently managed. If the mandrel is of iron it must, before being mounted in the bath, be covered with a thin deposit of copper in a cyanide of copper bath, otherwise the surface would be attacked by the free acid in the bath. As the copper is deposited on the revolving mandrel the burnisher presses with even but gentle force on the surface, and breaks down the crystalline formation, converting the deposit into a dense, reguline metal of greater specific gravity than ordinary sheet copper. The speed of travel of the agate burnisher is so arranged in relation to the depositing power of the current that, on the average, a layer of copper of not more than $\frac{1}{500}$in. in thickness is deposited in the interval between two successive passages of the tool over a given spot.

The tanks are arranged end to end in double rows, and between two rows is placed the line of shafting which drives the chain and wheel gearing by which the mandrels are rotated. Between the same two rows is also placed parallel to the axes of the mandrels a piece of shafting as long as the row, which is propelled alternately backwards and forwards for a distance equal to the length of the longest mandrel in the tanks, by a screw, resembling the screw of a lathe, and which is placed between the pair of tanks at one of the ends of the double row. This long piece of shafting carries on slide-bars, resembling the slides of a lathe, rests, to which are attached the burnisher-holders. If the mandrels are of small diameter two or more of them can be mounted in the same tank, the object being to expose approximately the same surface of cathode in each. The current passes away from the cathode through a copper brush—somewhat resembling the brush of a dynamo—which bears against the revolving surface of one end of the mandrel. The above operations are purely automatic and go on night and day. One attendant can attend to 50 or 60 tanks, and thus the process, in addition to its other advantages, has the merit of being very economical of labour.

One of the great advantages secured by the use of the burnisher over and above the superior quality of the metal obtained is that the current density per square foot of cathode may be from three to four times that made use of in electro-refining, or in ordinary electroplating. A current of 20 amperes per square foot is commonly made use of, and even 28 amperes have occasionally been employed with perfect success. The author need hardly point out the saving to be effected in the first cost of buildings, tanks, and gearing by the power thus conferred of depositing at a rapid rate. A current density of 20 amperes corresponds to a rate of deposit of nearly 9lb. per square foot of cathode per full week of 168 hours.

As in all electric processes, so in this, the greatest care must be taken to ensure that there is no loss of current to earth—such as would be brought about by leaky tanks—and no unnecessary outside resistances—such as would be caused by imperfect contacts where the branch conductors are joined to the mains. All the observations regarding the means of ensuring a perfectly pure copper deposit which have already been made with reference to electro-refining apply equally here.

It is absolutely essential that in cases where perfect continuity is desired in the metal deposited there should be no interruption to the current. The density of the current may be varied without producing a severance of the continuity of the metal, but if the current were stopped altogether, and oxides were present on the surfaces of the anodes, there would be generated a back current in each tank which would result in the partial oxidation of the surface of the cathode, and a break in the metallic continuity when the current was put on again would be the consequence. Even if there were no back current the surface of the cathode would oxidise in time, for it is well known that the free sulphuric acid in the bath would attack the copper in the presence of air, and in consequence of the rotatory motion of the mandrels, it is highly probable that a considerable portion of air is drawn into intimate contact with the surfaces. Hence, in cases where metallic continuity in the finished product is imperative, as, for instance, in high-pressure steam-pipes, or in tubes which have afterwards to be drawn down to a smaller diameter, it is essential that means be adopted to render the current continuous.

When the metal has been deposited to the required thickness, the tank in question is cut out of the circuit, the mandrels removed from it, and the liquor run out into a settling-tank where the sludge separates out. The copper tube which has been formed on it is then removed in one of several ways. It may either be expanded off by superheated steam if deposited on an iron mandrel, as copper expands more per lineal unit, when heated, than does iron; or it may be put into a machine and be subjected to the squeezing action of rollers which gradually travel along its surface, the effect being to slightly enlarge the diameter of the tube, and thus enable it to be drawn off the mandrel. If the mandrel, however, be of copper, the tube requires neither heating nor rolling, because the first film of copper that is deposited can, by a most ingenious contrivance, be separated from the body of the mandrel while still allowed to adhere at the two ends. When finished, the two fixed ends are cut off in a lathe, and the tube can be easily withdrawn.

(To be concluded.)

EFFICIENCY AND COST OF ELECTRIC LIGHT.

An admirable lecture was given before the Peterborough Scientific Society last week on the above subject by Mr John C. Gill, A.M.I.C.E., city engineer and surveyor, of Peterborough. The lecture was fully illustrated by lamps and batteries lent by the India Rubber Company, of Silvertown.

Mr. Gill first explained in an explicit manner the efficiency of the electric light as compared with gas in lighting power. The official unit of light is the candle-power, the light of a standard candle, six to the pound, burning 120 grains of spermaceti wax per hour. The lecturer here explained combustion of gas at burner, showed and explained the glow lamp, and how the filament is made incandescent by passing a current of electricity through it. Dr. Julius Thomson, of Copenhagen, has made some careful tests of the energy consumed in producing light by sperm-candle, oil, and gas, and gave the result as 12·28 foot-pounds per candle-power per minute, and as this confirms the results of other independent tests where electricity was also used, the mechanical equivalent of artificial light, taken for these calculations, was 12 foot-pounds per candle per minute. In producing light by coal gas and electricity, we start at the same place—the coal, and finish at the same place—the light. The energy taken from the coal at the commencement, and that delivered in light at the end, can be compared. The last Board of Trade return on the manufacture of gas in the United Kingdom shows the total quantity of coal used in 1890 amounted to 10,240,000 tons, and this produced 103,100 millions of cubic feet of gas. This gives an average of 10,066ft. of gas for each ton The total heating power of 1lb. of average coal amounts to 14,320 units, one English thermal unit being equal to 772 foot-pounds of work. The average quantity of coal used in making one cubic foot of gas is, from the foregoing figures, ·222lb., and allowing five cubic feet to give 16 c.p. for one hour, we get 11,520 foot-pounds energy in light from each 1·11lb. of coal. But each 1·11lb. of coal contains originally 12,069,412 foot-pounds of energy, so only ·095 per cent. of the mechanical energy in the coal is utilised, or, it may be said, the efficiency of coal-gas is ·095 per cent.

Turning to lighting by electricity, coal is used in a very different manner to produce the same effect. But the efficiency of the light as compared with the energy in the coal may still be worked out. The average consumption of ordinary coal to drive the dynamos in central station lighting may be taken at 2½lb per horse-power hour. Each horse-power at the engine therefore absorbs 35,800 units of heat per hour, or 27,637,600 foot-pounds of work. Now, an incandescent electric lamp of 16 c.p. requires 60 watts of electricity per hour. The mechanical equivalent of one watt of electric current being 44·2 foot pounds per minute, the 16-c p. lamp uses 159,120 foot-pounds per hour. One h p. would therefore supply 12·4 lamps each of 16 c.p. for one hour, or a total of 198 candles, which at 12 foot-pounds per minute would have a mechanical equivalent of 142,560 foot-pounds per hour. But it has been seen that to get this energy at the lamps coal is used at the boiler, the energy of which amounted to over 27 million foot-pounds, and working it out exactly the efficiency is ·516 per cent. The respective efficiences are therefore coal-gas ·095 and electricity ·516 per cent., the proportion being as 1 to 5·4. Both processes seem at first sight to be exceedingly wasteful, as by the better of them there is less than 1 per cent. of the energy in the coal utilised, while more than 99 per cent. is wasted. But the great object of the comparison was to show that electricity will give five times more light than gas from the same amount of coal, or, to put it in another way, 1lb. of coal will give five times as much light when used through a steam engine and dynamo as when made into gas. This fact must in course of time tell in favour of electricity.

Mr. Gill then proceeded to explain the electrical units, watt, ampere, and volt, and remarked: The time is coming when every ordinary mind will have a fixed idea of a watt of electricity, just as it has now of a gallon of water or a yard of ribbon. For the present purpose it is sufficient to bear in mind that one watt is 1-746th part of 1 h.p. A 16-c.p. lamp requiring 60 watts per hour of electricity, for 1,000 watts we should have 265 candles. Taking a flat-flame gas burner to give 12 candles for every 5ft. per hour consumed, we have 2,400 candles for each 1,000ft. of gas. The ratio between the lighting power of 1,000ft. of gas and one kilowatt of electricity is therefore

as 9 to 1, and to be of equal cost, light for light, the price of one kilowatt of electricity should be ⅑th of the price of 1,000ft. of gas. With the price of gas at 3s. 4d. per 1,000 cubic feet, as in Peterborough, the price of electricity to supply the same light at the same cost should be 4½d. per kilowatt-hour or Board of Trade unit. At Newcastle-on-Tyne the price is 4½d. per kilowatt, and therefore electricity is sold at Newcastle at the same cost, light for light, as gas at Peterborough. But it is hardly fair to want the electric light supplied at the same price as gas. It is so much brighter, purer, cleaner, healthier, and safer that its market value is higher. Thus we find that there is a great and constantly growing demand for electric light in Bradford, where it is sold at 6d. per kilowatt, although the price of gas is only 2s. 3d. per 1,000ft. Electric lighting has large collateral economic advantages when compared with gas. Enquiring whether the present price of electric lighting will be maintained, or whether there is any prospect of its being cheapened, the lecturer gave the reply with the greatest certainty that it will become much cheaper than at present. The day of experiment is passed, and the permanent electric lighting plants now erected are amongst the most efficient of machinery. But there is a monopoly in the manufacture of the glow lamps which keeps up the price. Two years hence the Edison-Swan patents will expire, the manufacture will be open, and the cost considerably reduced. Another reason why we may safely predict a lowering in the price of electric lighting is that the interest on capital and the maintenance expenses of a large central station plant are just as heavy when supplying only one-third of their full capacity of lamps as they are when running with a full load. This is just what is happening now, and the electric lighting industry is passing through that season of heavy outlays and small returns through which every new industry has to pass. It was exactly the same with gas when first introduced, and gas companies now pay good dividends. As with gas, so with electric light – the greater the demand the cheaper the supply. There can be no denying the fact that the past year has been one of extensive progress in electric lighting. The Act of 1888 made successful lighting by electricity supply companies possible, yet there are already companies registered whose authorised capital amounts to £5,300,000. This will compare favourably with any other new industry, and it must be borne in mind that this sum of five and a quarter millions devoted to electric lighting is independent of the electricity supply works established in many towns by the local authorities.

A vote of thanks was cordially given at the close.

CANTERBURY.

The following is the report of the committee selected to report upon the drafts of agreement and deed of transfer submitted to the Canterbury Town Council by the solicitors to the Brush Electrical Engineering Company, Limited:

The committee having had under consideration the drafts of the agreement and deed of transfer submitted by the solicitors to the Brush Company beg to report that in the opinion of the committee one of the first and most important points to be assured is the stability of the company to which the transfer of the Canterbury Electric Lighting Order, 1891, is to be made. The original proposition was that the Council should transfer the order to the Brush Company, or to a local company to be formed in all respects to the satisfaction of the Council, but in any event it was understood that the capital was to be £50,000, for which the Brush Company was to be answerable, it being proposed that a sum of £15,000 should be called up to commence with. The draft submitted to the Council provides for a transfer of the order to the Canterbury Electricity Supply Company, Limited, a subsidiary company formed under the auspices of the Brush Company and at present existing only in name, having no capital subscribed except seven shares taken by the seven subscribers to their articles of association, who are officers and employés of the Brush Company. The draft provides that the capital of the Canterbury Company shall be increased to £50,000, but it is proposed to start with a subscription of £15,000 only, and it is provided by the agreement that if there is a failure to obtain subscriptions to the extent of £15,000 before June 1, 1892, either party to the agreement may determine it. It is scarcely necessary to point out the difference in point of stability between a company with £50,000 subscribed and £15,000 paid up, and a company with a subscribed capital of £15,000 fully paid up. Having regard to the importance of dealing with a company of stability, your committee consider that if this transfer is to be made to the Canterbury Company, the Council should have safeguard by the Brush Company's guarantee to the extent of the £50,000 capital, so that the money may be called up and may be forthcoming as required.

It was stated on the original proposition that the Brush Company would commence the work of electric lighting directly a transfer of the order was made, but the present draft makes the whole transactions depend on the raising of £15,000 by this Canterbury Company. If, however, the precautions suggested above as to transferring to a stable company are adopted, this difficulty disappears.

The committee further consider that the compulsory area of supply should be increased by the inclusion of Bridge-street, Broad-street, and Palace-street.

With reference to the powers for the Council to repurchase the undertaking, your committee consider that no claims should be made for compulsory purchase, and provisions are required that at the expiration of 42 years the Council may repurchase under the terms contained in the Electric Lighting Acts.

No limitation is contained in the draft as to the amount of dividend which the company taking over this order may make, but your committee consider that it is most important that there should be some limit, and propose that after the company has received a cumulative dividend of 7 per cent., one-half of the excess profit shall be applied in the reduction of the price of electricity and the remaining half shall be taken by the company.

Provision should also in the opinion of your committee be made for the following matters:

That the company taking the order shall not transfer to any other company without the consent of the Council.

That the expenses incurred by the Council in negotiations and in the transfer of this order be paid by the Brush Company, this being part of the terms arranged.

That the cost of obtaining the provisional order, not exceeding £350, shall be paid by the Brush Company on completion of the transfer of the order.

That the local authority or the undertakers may apply to the Board of Trade every seven years for revision of the maximum price.

That the usual provisions for security and execution of works—the keeping and audit of accounts – and other necessary powers and provisions for the protection of the local authority, and which are usually inserted in provisional orders granted to companies, be embodied in any document transferring the order.

That no promotion-money shall be paid by the Canterbury Company.

That the order shall lapse to the Council if the company taking the order fails to carry out its obligations.

Alderman Cross, in moving the adoption of the report, said they would see that the sub-committee had gone very fully into the matter of electric lighting. They had had the provisional order before them and had gone through it in detail, and also the agreement drawn up by the Brush Company. The whole of their proceedings had been embodied in the report, and he would, therefore, without any further remarks, move its adoption, and that a copy of it be sent to the solicitors of the Brush Company.

The report was adopted.

CHESTER.

The following report by Mr. Alderman Gilbert, Mr. Councillor Stevenson, and the city surveyor, after their inspection of various installations, has been presented to the Chester Watch Committee:

Brighton.—Brighton represents the two systems of distribution in operation in the same town—viz.: 1. The high-pressure alternating current, supplied by the Brighton and Hove Electric Light Company. 2. The low-pressure continuous current, supplied by the Corporation of Brighton. His Worship the Mayor received the deputation most courteously, accompanied by Mr. Moon, chairman of the Lighting Committee, and other members of the Town Council, with Mr. Tilstone, the town clerk, Mr. Wright, local manager, and Mr. Nebel, superintendent of works, from whom the following information was obtained: The high-tension electricity is distributed by means of overhead wires from the Brighton and Hove Electric Light Company's central station. The company has existed for upwards of 10 years, and the Town Council are somewhat indebted to them for working up the business which, though steadily increasing, is stated to be at present an unprofitable one. The company unsuccessfully applied for a provisional order, and opposed the one granted to the Town Council. Subsequently there were negotiations to purchase the company's goodwill and plant for £7,000; this was not carried through, as the Town Council would not adopt the Lighting Committee's recommendation. A slight variation in the light was observed for a short period at the hotel at which the deputation stayed, but printed testimonials show that consumers are very well satisfied. The installation was by Messrs. Hammond and Co., electrical engineers and contractors, who have also been engaged on the central stations, etc., at Eastbourne, Hastings, West Brompton, and Madrid. This firm's tender has lately been accepted for the first installation of the light for the Dublin Corporation, under Mr. Harty, the borough surveyor, and Mr. Manville, electrical engineer. The streets of Brighton are lighted by gas only; the gas works belong to a company, the charge for gas being 2s. 9d. per 1,000 cubic feet, and it was observed that the majority of the tradesmen were not supplied with the electric light, and that the larger hotels provide the electrical machinery and appliances for their own lighting purposes; and, notwithstanding that the town of Hove is served by this company, it has advertised its provisional order for sale. The Town Council of Brighton have borrowed £30,000 for a period of 30 years, and are now applying for a supplementary loan of £8,500; the eventual total cost of the installation (including £7,000 for site of station) is estimated at £42,000, and this sum it is calculated will supply 10,000 lamps (the usual average, 5,000, being lighted at one time). This station is now supplying 2,500 lamps with current at 7d. per Board of Trade unit, the number lighted at one time being, say, 1,200, and the largest single installation being 300 lights at the Alhambra. The Corporation cannot ascertain profit or loss, having had only two months' experience; an opinion was expressed that loss must arise

on the present output, but that if the maximum is supplied, profit may be made, as the only increased outlay will be in the direction of wages, fuel, etc. Coal costs at Brighton 22s. per ton, the best Welsh steam coal being preferred. The Mayor and members of the Council consider the low-pressure continuous-current and storage battery system the best for compact areas (1¼ miles greatest distance), and therefore for Chester. They advise keeping the order in the hands of the Corporation, having great faith in the future of the electric light. The electric light cost, calculated lamp v. lamp, is double that of gas, but greater illumination is obtained; the consumers' expectation is met by giving a better light, besides improved conditions of health and cleanliness; smaller fire risks, clearer atmosphere, and non-destructive effects are also advantages which are claimed for the electric light v. gas. A very successful installation was examined at the shop of Mr. Cowell, North-street, and that gentleman expressed himself highly delighted with the result, and from enquiry at the hotel the cost of five lamps supplied with current by the Brighton and Hove Electric Light Company for three and a quarter hours is 7d. The Corporation do not put in the fittings on the consumers' premises. It was noted from the experience at Brighton that sub-contracting would not give the best station results; that limited space is undesirable; that the testing-room should be away from the works; that duplicate steam-pipes would be advantageous; and that the appliances, such as switches, etc., should not be placed in immediate proximity to the engines. The area of supply equals one mile square, and up to the present time about 20 miles of cables have been laid in small subways under the footways, etc., of the streets. The land on which the central station is erected is about half an acre in extent, and the plant consists of: Three Lancashire boilers, 28ft. by 7½ft., one as a stand-by, with space for three additional; three compound direct-coupled engines, each developing 98 i.h.p. at 450 revolutions, and supplied by Messrs. Willans and Robinson; dynamos, apparatus, electric instruments, and appliances were supplied by Messrs. Siemens Bros, Goolden and Co., and others; two sets E.P.S. batteries, first cost £2,700, estimated life four to five years; several descriptions of meters in use, ranging from 25 to 100 lights, highest price £10, prime cost; the Aron £5, or on hire 10s. per year. One lamp will hardly register in certain meters. The Edison is considered very accurate. The Corporation keep in repair and regulate all meters. The working hours at the station are from 2 p.m. to 10 p.m., when steam is shut off, the batteries supplying current for the remaining 16 hours. Sixty-six lights were being supplied at the time of visit—11 a.m. The electrical engineer employed at Brighton, as also at Bradford, Portsmouth, and St. James's, Pall-mall, was Mr. Shoolbred; the principal contractors were Messrs. Sharp and Kent.

St. Pancras.—The Vestry of St. Pancras (pioneer in London of municipal enterprise in relation to electricity) commenced their supply on the 9th November, 1891. The installation is of a first-class type, and the latest example of the low-pressure continuous-current and storage battery system, as applied to street and house lighting, and for motive power. Mr. Pyecraft, the vestry clerk's representative, and Mr. Baron, the official in charge, were present at the inspection, and they considered that the low-pressure system would economically serve areas with distances extending three-quarters to one mile, and with sub-stations at 1¼ miles, the extreme distance in the lighting area of St. Pancras being 5½ miles from the central station. The capital expenditure is made up as follows—viz.:

The site	£10,000
Buildings and plant, including five miles of mains	50,946
Royalty for use of three-wire mains	909
Commission	1,988
Sub-station	550
Weighing machine	100
Public lighting (90 lamps)	900
Meters	1,000
Opening expenses	50
Contingencies	3,557
Total	£70,000

This sum is to cover an installation of 10,000 16-c.p. lamps or their equivalent. The charge per Board of Trade unit is 6d., and contracts for supplies equal to 6,000 lamps have been sealed by the Vestry. The lamps for street lighting are supplied direct, and are of excellent design and fixed on the central line of the carriageways at average distances of 50 yards. The current is supplied by two dynamos for this direct lighting. The steam is shut off at certain hours for the house lighting, and if current is then required, it is served by storage batteries and the three-wire system of main distribution. The cables are laid in brick and concrete subways under the footways and carriageways, and dry air is driven through the subways from the central station to expel moisture, etc. The chimney stack is 170ft. high, and the exterior is utilised to assist the condensation of steam, by means of large exposed surfaces of corrugated iron plates affixed thereto. Coal is supplied to the station at 21s. per ton. Six Babcock and Wilcox boilers, working up to 240lb. pressure; 11 Willans and Robinson's triple expansion engines, 170 h.p., with a system in application for condensing; Kapp's dynamos; Brockie-Pell arc lamps for street lighting; Electric Construction Company's No. 55 battery, having transparent glass containers. The loss on storage equals 15 per cent. Measurement of electricity by meters. Charge 2s. 6d. per quarter (smallest size). Prime cost of Ferranti's meter, £6. Frager's meter working similar to clockwork. Prof. Henry Robinson was the electrical engineer employed by the Vestry.

Eastbourne.—The Eastbourne Electric Light Company is stated to be the pioneer company of electric lighting. Capital £28,000. Debentures pay 6 per cent. The old central station has been removed, and changes have been and are being made in the machinery, and this is now fixed in an old building formerly used as a brewery. The Corporation opposed the company's provisional order up to the last moment; and the Board of Trade imposed underground wires, which are carried under public streets in cast-iron pipes; 12 miles of mains are laid. The majority of the shops take the supply; the furthest point of supply being 2½ miles distant from the station. The high-pressure alternating current of 1,800 volts at the central station is transformed by converters to 100 volts on the consumer's premises. The Brush electrical machinery, driven direct from a special engine, is used for the Parade lighting, starting one hour before sunset, and closing down at 11.30. This public lighting consists of 16 Brush arc lamps, 1,000 c.p. to 2,000 c.p., each of which costs 3¼d. per hour, or a total for the 16 lamps of £480 per year. The number of incandescent 16-c.p. lamps is given as 2,000 to 3,000, and a total of, say, 6,000 could be supplied with the present plant, price 10d. per unit—coal 26s. per ton. The day's run commences two hours before sunset, and ceases at 1 a.m., an ordinary semi-portable engine working the remainder of the 24 hours. The plant, as altered, includes Fowler's tubular boilers, 140lb. pressure; Fowler's 150-h.p. compound engines, driving dynamos by belting, and working up to 200lb. steam pressure; Elwell and Parker's dynamos, running at 400 revolutions per minute; Westinghouse meters hired at 5s. per quarter; prime cost ranges from £3. 10s. to £5. The engineers and contractors employed were Messrs. Hammond and Co.

West Brompton.—The West Brompton House-to-House Electric Company was formed in 1889, and the provisional order was unopposed by the Vestry. Capital of company, £70,000. Last week's net profit said to be £180. The installation was the best example which came under the notice of the sub-committee of the high-tension alternating current system with transformers to low tension conveniently placed at or near the premises and small areas supplied with electricity. Mr. Gay, manager, lucidly explained the arrangements, aided by a plan of the district showing all the wires laid permanently or temporarily, with buttons indicating the number of lights for each consumer. The central station is designed for extension up to 12 engines and dynamos to supply 40,000 lamps; at present there are 19,000 lamps installed, the number lighted at one time being about 8,000. The charge made is 8d. per unit; coal 22s. per ton. The representatives of the company are strong advocates of the method of distribution by means of high-tension electricity, the great advantage claimed being the easy method of supply to one or more consumers at considerable distances from the central station; it is said there will be little difficulty in transference to low tension when the area of supply becomes more compact. It is stated that the first heavy cost of machines and mains to supply a few consumers at long distances on the high-tension system is fully counterbalanced by the cost of the four required sub-stations to the square mile, and the battery storage loss rising up to 30 per cent. under the low-tension system. There are 20 miles of mains laid in cast-iron pipes the largest diameter of pipe being 6in. The plant consists of four Babcock and Wilcox boilers, 120lb. to 145lb. pressure; four Fowler's compound horizontal (non-condensing) engines, one only working after 12 p.m.; Lowrie-Hall type of dynamos, driven by ropes from grooved flywheels of engines; Westinghouse meters, small size hired at 5s. per quarter. Messrs. Hammond and Co. were the electrical engineers and contractors to this company.

It will be observed that the coal cost at Chester is but one half the price paid in the towns visited, and this fact, coupled with information derived from various returns, documents, pamphlets, and estimates, demonstrates that Chester is well circumstanced and favourably situated for an installation of the electric light, and as "time" is an important element as regards the lapsing of the Town Council powers under the provisional order, the members of the deputation advise—

1. The introduction of electric lighting for part of the area within the city boundary.

2. That the central station be so designed as to be capable of development with the smallest possible rebuilding, or alteration of machinery.

3. That not more than £15,000 to £20,000 be expended in providing a first installation.

(*Signed*) LEONARD GILBERT, ANTHONY STEVENSON.

COMPANIES' MEETINGS.

CITY AND SOUTH LONDON RAILWAY COMPANY.

The fifteenth ordinary general meeting of this Company was held at Winchester House, E.C., on Tuesday morning, the chairman, Mr. Charles Grey Mott, presiding.

The **Secretary**, Mr. W. F. Knight, having read the notice convening the meeting,

The **Chairman** said: Before proceeding to move the adoption of the report, I am sure I shall be expressing your feelings as well as my own in saying how much sorrow and sympathy we have felt with the Prince and Princess of Wales in the loss of their son the Duke of Clarence. His loss has been a sorrow to the whole country, and the whole country has sympathised with it. But to us it comes home especially, for it is now little more than a year

ago since he was present at the opening ceremony of this railway. He came there at his own request. He took a strong interest in the line, and showed that he fully appreciated the great benefits that a line like this might bring to this country as well as to others. I am sure that we all feel and will desire to express our deepest sympathy with the Royal Family in their sad bereavement.

It now becomes my duty to move that the report and accounts now presented be received and adopted. I regret that we have to meet you again without the declaration of a dividend on the ordinary stock. During the first half of the present year we had, in company with many other lines, an unsatisfactory traffic. Our line is especially affected during the holiday season by the absence of our regular travellers, but we expected that this would be far more than made up by the increased traffic which we should receive owing to the cricket matches at the Oval. Unfortunately, the weather was so extremely bad, as you know, during the whole of that period that there was hardly a match that was in any respect a success, and we got little or no additional traffic from that source. The result was that our average receipts for the first quarter of the half-year were only £704 a week. After the holiday season was over, and people began to get more confidence in our line, our traffic began steadily to increase; so much so that in the second quarter of the half-year our average receipts were raised to £802 per week. We have tried to improve. We thought that part of the want of increase in traffic in the first half might be due to our fares being in excess at some periods of the day, and that a reduction of these fares might produce an increased income. We did reduce and vary them, and on the whole we think that so far the reduction has been successful. But in some cases we have since found that we can increase them again without losing the traffic, and we are taking every opportunity we can of carrying out that policy. The reduction of the fares is evidenced in the following way: The average fare for a passenger in the first half of last year was 1·9d. In the second half it was reduced to 1·7d., inclusive of season-tickets. The reduction of that decimal between ·7 and ·9 amounts to more than £2,000 in the half-year, but it has been more than made up by the increased number of passengers we have carried, and so on the whole of the half-year we show a total increase in receipts of some £600. When we began to raise the fares, as we did on the 1st November last, we introduced a system of season-tickets which has been largely availed of, and the number is steadily increasing, and I am glad to say that those which have just expired are nearly all being renewed, showing that the season-tickets have met a demand, and that we are giving satisfaction to their holders. The great fault of the line is the want of traffic and of sufficient receipts. Our receipts per train mile are 2s. 1½d. Now the average receipts of some of the railways in England are about 5s. per train mile, and on passenger lines they usually somewhat exceed that figure. Our expenses per train mile have been only 1s. 7¾d. The expenses of an ordinary steam railway are 2s. 9d. So that, you see, our expenses per train mile are very much lower than in the case of steam trains. But, of course, our trains don't carry as large a number of passengers as those on an ordinary steam railway. I will come to that point directly. Our total expenses appear to be very high—they always are high in the early stages of a new railway—they amount to 76 per cent. of the receipts for the half-year. But when you compare them with those of an ordinary railway you must recollect that we have, in addition to the traffic of a steam railway, the lifts which take the passengers up and down, which are, of course, quite extraneous to ordinary railway working on the surface. If you deduct the cost of working these lifts, you will find that our expenses for the past half-year are reduced to 66½ per cent. of our earnings, which is a fair comparison with a steam railway. If our receipts had also increased at so fair a rate that instead of having a little over £20,000 we had had £30,000, we could have carried that traffic at little or no practical increase in expenses, and our working expenses would have been reduced from 66½ per cent. to 45 per cent., which is lower, as you know, than almost any steam railway in the kingdom. In the early stages of a railway, as I said, the percentage of expenses is always higher than is the case afterwards, as the traffic develops. I will give you one or two instances which will show you this. The Brighton Company's expenses in 1867 were 85 per cent. of their receipts. Their expenses last half-year were 48¾ per cent. of their receipts. So that you see the growth of traffic brings down that percentage very largely. About the same time the London, Chatham, and Dover's percentage was 71. Therefore, as far as our position compares with theirs in point of age, we are very much in advance of what they were at that time, because we are only a year old, but at the time I have quoted these railways were many years old. Our expenses this half-year have shown certain decreases, which have unfortunately been counterbalanced by certain increases on the other side. Some of these are such items as increase in compensations, one or two claims brought against the Company which we thought it better to settle. They were not very just claims, but they were small things, and have cost us £92. Rates and taxes increased to the extent of £152 over last half-year. Locomotive expenses have decreased by £383, and traffic expenses have decreased by £38. Maintenance of line has increased, because we have the whole maintenance upon us this half-year, whereas we had not in the last half-year. There is a small increase in general charges. The result of this is that the expenses as compared with the previous half-year show a trifling decrease. I am sure it will be very interesting to you, after we have had a year's experience of working by electricity, that I should give some facts and comparisons in regard to it, which we were not able to give before. Of course we cannot say for a moment that the present condition of our working is by any means perfect. We are improving it every day, and I hope we are going to lessen its cost. I will give you a few of the results which we have learned so far during our experience of the last 12 months. Look, first, at our locomotive expenses, which are, after all, the key to the question of electricity *versus* steam. These expenses are 7·88d. per train mile. Now, the locomotive expenses of the main lines of the country, such as the North-Western, Great Western, Midland, and Great Northern, will be something over 9d. per train mile over the past half-year, against our 7·88d. But that is not all. Our charge of 7·88d. includes a price for coal which covers all the carriage from collieries and carriage to our depôt. In the accounts of the other companies the coal is charged as at the pit's mouth, and there is no cartage put on it at all. If you deduct from our accounts for coal the amount which we should have paid for it if we had been in the position of the other companies, you will find that our cost per train mile is reduced to 6·6d. against their charge of 9d. The expenses per train mile of the large companies which pay carriage on coal, such as the Brighton, are not 9d., but over 10d. In reference to the relative economy of electricity and steam, it will be interesting to consider what are the advantages which we can claim for electricity. We have told you in our report that "after the experience of the past year, there is every reason to be satisfied with the use of electricity as a motive power for the working of this railway, and for a confident belief that when all the details are fully perfected it will be found to be at once safe, convenient, and economical." Its safety we have proved, because we have had no accidents. Its convenience is, I think, proved, and will be far more so in the future than in the past. Its economy is what I am now coming to. I have told you that our expenses were 1s. 7¾d., against the usual steam railway figure of 2s. 9d. per train mile. Their (the steam railways) reply to that is, of course, "Your trains are very much smaller and lighter." Well, that is perfectly true. But you must recollect this, that the average number of people that we take in a train—in fact, have taken in the last half-year—is 47. We are really capable of taking three times that amount. The ordinary steam trains all over the country carry 45 passengers per train mile, and the rest of what they carry is deadweight, that is not paying them. I hold that, instead of running huge trains only partially filled, it is better to run smaller and lighter trains which hold a vastly larger proportion of passengers to their weight; and that you had better increase the number of these light trains than have fewer ones of very much heavier weight. It is more conducive to the public convenience, and in the end will, I think, be found more economical. One of the results of our working is this: In an ordinary steam train it is generally reckoned that a ton weight of carriages will provide for three passengers. Of course I am not speaking of trains like the Pullman, but of ordinary ones. In our trains for every ton of weight we can accommodate five persons, so you will see that in our electrical arrangements we have a decided advantage in point of weight over a steam railway. I was very much surprised on reading a report of the Metropolitan Railway meeting the other day to see it stated that that very able and experienced railway chairman, Sir Edward Watkin—whom we look upon as an especial expert in railway matters, and whose opinion is always valuable—had told his shareholders that he had considered the question of electricity, but that he understood that an electrical engine could only draw a train equal to its own weight. Now let us see how far that is correct. An ordinary steam-passenger locomotive such as run on our main lines will take, it is usually reckoned, three times its own weight behind it. That is to say—I am speaking of passenger trains—that if you have an engine 80 tons in weight, it will take 240 tons behind it. Our electric engines are at the present moment always taking more than three times, and even four times their own weight. And you must recollect that in running over our line we are taking that weight up an incline, the ruling gradient of which is 1 in 27, with a reverse curve of about two chains in radius. Now Sir Edward has not got a steam engine which will take an incline like that. We are therefore surpassing with electricity the powers of steam relatively to the work done. These are important facts to have learned in our last twelve months. Our average speed of working at the present moment is 13 miles an hour, including stoppages. We ought to work, and we reckon to work, rather faster than that, and we hope to do so one of these days, but you will recollect that that is considerably above the average speed of Metropolitan Inner Circle trains. They don't attain a speed of 13 miles an hour including stoppages. I think I have shown you in figures that although electricity is only in its infancy as regards this line, which is the first of its kind, and has only been in operation a year, and there has been no time or opportunity to really perfect it, though we improve it from day to day, I think you will see that electric power in the future is not a matter that the engineers can afford to despise. I confess that, having had a very long experience of the management of steam railways in this country and elsewhere, I cannot help feeling that the facts that we have learnt in the past year point to the substitution very largely, and at no very distant date, of electricity for steam over the railways of the world. It is always well when you have got to a certain point to look back and see what your expectations were. If you will look back to our original prospectus—it only referred to the line to The Elephant and Castle—you will find that we estimated for a very high traffic. I believe, if you will follow our advice and allow us to carry out the plans that we have in view, that the time is not very distant when these traffic expectations may be realised, large as they were. If you look also at the expenditure, you will find that in our first estimate—and you recollect that that was an estimate based upon what was supposed to be an extremely economical mode of working,

viz., the cable system—the amount of our expenses proportionately per mile rather exceeds the amount at which we are now working. After I had gone into that estimate very carefully, I considered it very doubtful if it could be adhered to, that it was too low, and in the second prospectus we raised it considerably. I don't think, from what I know, that it would be possible to work this line by a cable system, even if we desired to do so. The cable is an excellent system for certain purposes, and it is extremely good where there are a number of hills, because there you get the effect of gravitation one way helping to ascend the other. On the other hand, to work a railway such as this with the enormous traffics we should have, and are likely to have, by the cable, would involve an enormous strain on that cable, and would require a very strong and heavy one—so heavy that its weight would probably be twice the weight of all our locomotives put together. Then the difficulty of working round a curve, and the friction involved in working over pulleys in a line of this kind, would be very great. It appears to me, therefore, that our views as to expenses are fully borne out. It is clear that if you have that very large weight (the cable) to move before you move the train, combined with friction, you cannot have as economical an arrangement as with light electric engines. I think, therefore, you will see that we are justified in what we have stated in the report, and that the future of our electrical working is a very promising one indeed. Most of our line—nine-tenths of it—is a good one and well constructed; one-tenth, I am sorry to say, has been an engineering blunder—that is to say, King William-street Station and the inclines leading to it. The station is too short, the inclines are too severe, and the curves are very heavy indeed as you come into it. We want, if we can, to add another carriage to our train. We can't do it because of King William-street Station. The inclines also up to that station are at the present moment involving us in a vast expense for additional power, that would be quite unnecessary if we could get rid of them, and if we could do this we could work the line very much cheaper. The station cannot be enlarged, because there is the Monument in front of us, and we are not allowed to approach nearer to that structure, while on each side we have very large buildings, the ground on which they stand being mostly made ground, having been raised at the time that London Bridge was built. Therefore we have only to consider if we cannot in some way get rid of the station and inclines, which constitute only a very small portion of our line, a few hundred yards, and fortunately not a very expensive portion, while it would always be extremely useful even if we substituted other lines for it at a future date. In order to improve and get our line into such a condition that we can work it economically and meet the growing traffic, we think there is no means other than by making a through station in the City instead of having a terminable one. All the steam railways that come into the City, with the exception of the Metropolitan, have terminal stations, and much they regret that this is so. Everyone of the terminal stations are taxed to their utmost with a constantly increasing traffic, and have a problem to solve which it will take the very wisest heads to deal with in the future. With a terminal station it takes from four to five times as long to deal with a train as it would if it was a through station. So you have to have large siding accommodation, which is always getting choked, and yet it is almost impossible to extend it. You know the enormous expenditure the Great Eastern are going to in widening Liverpool-street Station, and yet it will only be a few years before the block will come upon them again. With all this knowledge before us we feel that before we have gone to the expense of making an extensive terminal station, it is wiser at once to take the line through the City, and make our terminal station where we can acquire land at very small cost. If we can have through services you will at once see the enormous difference they will make. We can deal at once with the growing traffic; we can accommodate the excess traffic in the morning and evening, and at very much less cost per train mile than we are doing now. We have power far in excess of our immediate wants—if only we could utilise it we could work a much longer length of line than we are able to do now. All this points to the wisdom and desirability of carrying out the plans which we have now deposited in Parliament (Islington Extension Bill). We have looked about us to see in what way we can make these plans work as economically as possible. We have arranged with the Brighton Company for a station at the bottom of Denman-street, and they will be able to throw upon us at once a large passenger traffic. The moment that station is opened it would be utilised to a very large extent quite apart from the additional facility it would give to our own line, and the traffic that would naturally come from passing through the City, and the traffic promises for that line are exceedingly good in every way. But we felt, in our present financial condition, we might have some difficulty in raising capital to carry out the work; we have therefore taken power for carrying out such portions of it as are necessary by independent capital. Having control of it, however, we can make arrangements by which this Company will have all the benefit without the risk, and I think we see our way to find the capital. This question of independent capital or not, is not to be determined now, but after the Bill has been obtained. It will then rest with the Company whether they carry out the work or not. I would gladly have postponed the application to Parliament if we could. We considered every possible means of coming to you and saying, "It is desirable to postpone it"; and it is only under the strongest feeling that you cannot, with proper regard to the interests of this Company, postpone that application—no! not for a year—that we put it before you. We have considered the matter in every way, and we have come to the absolute positive conclusion, that it is essential to the interests of the Company that that Bill should go on. We ask you as Directors—we have a good deal of knowledge which we cannot quite impart to you, because it would only injure the Company—we ask you for your confidence and to pass the Bill. If there are any here who think that that Bill is not in the interests of the Company, then as far as I am concerned I must bow to your decision, but I say that I am not prepared to carry on the business of the Company if this is your mind. I am so thoroughly and completely convinced that the future success of this line is promptly assured if that Bill goes on, and is certainly risked if it doesn't, that I am prepared to place my position before you on that question. I now beg to move that the report and accounts be received and adopted.

This was seconded by **Mr. Sampson Hanbury.**

Mr. Turnbull asked as to the hitches that had occurred on the line from time to time.

Mr. Drake thought their little enterprise ought not to be compared with large railway undertakings. Theirs was a useful and might prove a profitable line, but it was very small, and if they carried out the Clapham extension in accordance with the Bill they had obtained but not utilised, he thought they might hope eventually to attain to a fair remuneration for the money they had expended. Whatever was the outcome of the application to Parliament for the extension to Islington, one thing was very certain—viz., that heavy charges would come upon that Company. Lawyers, philanthropists though they were, did not work for nothing as a rule. The line was esteemed by all to have the three points of safety, speed, and comfort. It was a necessity now for the locality through which it ran. He would submit that having 3d. to spend, they should not try to make it do the work of 2s. 6d. or 3s. He advocated the carrying out of the extension to Clapham, by doing which they would be making certain if slow progress.

Mr. Middleton congratulated the Board on the reduction in running expenses, but would impress on them that there was yet scope for considerable further reduction in his opinion. He hoped they and the officials would devote their energies to this question rather than to that of the extension.

Mr. Van Laun asked whether it was a fact that electricity as a motive power had practically failed on that line. He felt sore at coming year after year to hear the same story that they were not to receive a dividend. They did not want to be too hard on the Directors; still, they were responsible for what the engineers had done, and the engineers had practically misled the Company. He noticed, with a certain amount of bitterness, that they were asked to extend this failure. He represented two companies that held £10,000 in the Company's shares, and they wanted to know why the shares stood at the price they did. His directors were under the impression that this experiment had failed, and although the Directors had succeeded in paying debenture interest by careful management, yet they were in the unfortunate position that if some mistake the engineers had made was not corrected they would never receive a dividend on the ordinary shares.

The **Chairman** said he would reply to Mr. Van Laun first. He could certainly assure that gentleman that, so far from considering electricity a failure, he thought, from what they knew of it, it was the most decided success from the point of view of locomotion, and promised to be in every way a most satisfactory mode of working that line of railway. Of course, they could not be supposed to earn a dividend until they had worked the line, and they had only had one year in which to work it. During that time they had not only paid their debenture interest, but they had carried forward an amount that might have been distributed in a very minute dividend. The Board did not wish this, however, because they believed that when they next met the shareholders it would be to declare a dividend on the ordinary stock. He confessed he did not see any reason to suppose that they would not be in a position to do so, provided everything went on as they arranged. If shareholders thought the Directors were not to be trusted, then, of course, they must not hold the Board responsible for the results of the future. He could only say that their experience was that electricity was in every way a satisfactory power. As to the stoppages on the line. They were under the glare of the light of public opinion, which was directed on them at the present moment as a new undertaking, and people tried to find out every possible fault they could. They did have stoppages, and not unfrequently, generally lasting from five to ten minutes, seldom more than that. Unfortunately, they always occurred during the busy time, and arose from the strain that was put on the motors of the engines in coming up the incline into King William-street. It had been found in the course of time that the mode of winding the original armatures was not perfectly satisfactory, and owing to this short circuits took place. These would have been remedied at once if the Company had had a large surplus stock of locomotives, but they had not, and they could only take them off as they could be spared. This had been going steadily on for some time. They were rewinding the armatures, and had had no breakdowns with those that had been rewound. As the process could only be carried out by degrees, every now and then an old armature would break down. But if they were delayed 10, 20, or 30 minutes on any of the leading railways entering London, they did not at once write to the papers. Whereas, if they were delayed on the City and South London for 10 minutes, such was the confidence of the public in it that they were always expected to be punctual, and so it was thought more of. In course of time, when the armatures were completed, these breakdowns would be of very rare occurrence. The strain of coming up the incline to King William-street was, however, very great (a steam locomotive could not do it), and would always involve a waste of power. They were doing all they could to reduce expenditure, and so far from being unable to make the line pay, there was no doubt they could make it remunerative up to a certain point. He was quite sure that if they did not look forward

and go for that Bill (the Islington Extension), they would be very sorry for it in the future. He had no interest in saying this beyond the interest of the concern. He told them, from his experience and knowledge and from information the Board possessed, that they would be extremely foolish if they did not authorise the Directors to carry out the policy they had most carefully considered. He then put the motion for the adoption of the report, which was carried unanimously.

Mr. C. R. Grenfell proposed the re-election of the retiring director, Mr. C. G. Mott (the chairman) remarking that they must have come to the conclusion, from what they had seen of him, that he was the right man in the right place.

Mr. Edwin Tate seconded, and the motion was carried unanimously.

The **Chairman** briefly returned thanks for his re-election, remarking that the City and South London had hardly been out out of his thoughts for years. He was most thankful that at last he saw daylight, and a future which, if only shareholders would trust the Board, would place it in a far better position than any other railway in this country.

The auditors, Messrs. Turquand, Youngs, and Co., having been re-elected, the **Chairman** moved that the dividend of 5 per cent. on the preference shares be declared, which was duly seconded and carried.

The meeting then resolved itself into a special general meeting to approve or otherwise of the Bill empowering the City and South London Company "to make an underground railway to Islington, and for other purposes," which is being promoted in the present session of Parliament.

The **Solicitor** having read the principal clauses of the Bill,

The **Chairman**, in moving that the Bill be approved, said he had already dealt with it, but he would like to explain more exactly the necessity for it. He had touched on the objections to that part of their line running under the Thames and into King William-street Station. They had already got power to make a station at the end of Denman-street, which led from the Borough to the London Bridge Station of the Brighton Company. They were unable to carry out this work, however, because they found that the Brighton traffic was very large, and came in in immense quantities just at the time when they were busiest on their own line, so that if they had made the station they could not carry the traffic, because they could not work sufficient trains into King William-street Station. It would require a very large and rapid train service in addition to that which they had now. There was a great outcry amongst both South-Eastern and Brighton travellers because they had no means of getting into the City, except by walking over London Bridge, and he (the Chairman) did not see that there was any other mode than by such a line as he had proposed. Other companies were in the same condition. The South-Western had deposited a Bill for making an electric railway from Waterloo Station to the Mansion House, and the Great Northern had deposited a Bill for making a similar line from their junction at Finsbury to Finsbury-circus. All of them thought that these railways were the best and only means of getting into the City. The Brighton Company had agreed that they (the City and South London) should construct a subway from their proposed station to the former company's platforms, and passengers would walk down to Denman-street Station and thence get into the City. In order to get rid of the present incline, and have a fairly good one into the City, they proposed to go back further than Denman-street, and join on to their present line, and to make two new tunnels from that point past Denman-street under the river, coming out at the upper part of King William-street, near Lombard-street. The line would then be continued under the Central London Railway, with whose Mansion House Station it would have communication, and thence up Fenchurch-street and along Moorgate-street to the Metropolitan Station, with which it was proposed to connect, and also with the Finsbury Station of the Great Northern Railway. The line would then be continued by the City-road, with two intermediate stations, until it got close to The Angel at Islington. Here there was plenty of space and cheap land, and here they could deal with a rapid morning and evening service at a moderate cost. The line should collect an enormous mid-day traffic, which was one thing they wanted to make large dividends. The cost of carrying out the proposed line would be very moderate per mile, not as much, he thought, as the present line had cost. The only special expenses would be for stations, and in connection with the most expensive of these they had promises by which they would be able to largely recoup the expenditure. The line had been very carefully laid out with a view to the greatest possible economy in construction. The Chairman then reiterated his former remarks as to the impossibility of postponing the Bill, and explained the reasons for not doing so. It was a matter on which they must have confidence in the Board. Had they, he said, with some feeling, deserved a want of confidence, had they done anything that shareholders ought not to have confidence in them? On the contrary, he thought the time was come when the shareholders would acknowledge that the labours of the Board had not been in vain.

Mr. Hanbury seconded the motion.

Mr. Middleton, before going into the merits of the case, wished to entirely disabuse the mind of the Chairman and his colleagues as to any opposition on this point having anything to do with a matter of personal confidence in the Board. He thought the way n which the Chairman was re-elected should show that. As to the proposed Bill, he entirely and absolutely—speaking on behalf of £270,000 worth of stock—disapproved of this extension to *Islington* for many reasons. He—and his co-shareholders—thought the short line, the City and South London, should have a fair trial' that everything should be done that could be done to prove whethe or not it could be worked at a profit. The time seemed somewha distant when they were to have any ordinary dividend The Chairman himself had said that the line was a good one, and a good and improving property, and he would counsel shareholders to remain with that and work upon the lines of improving rather than extending it until they saw where they were. He was afraid there was a feeling abroad that they were a railway only, and wanted to get further afield. The original idea of that line was one to get the people of South London into the City; let them carry that out and improve the working before expending their capital of £800,000, and adding to it a capital of one million odd. He would beg to propose an amendment, that in the opinion of that meeting the Bill be not proceeded with for the present. The time might come when they might find it advantageous for them to go to Islington. If they could get a three minutes' service on the line it would add 25 per cent. to their receipts without adding anything hardly to their costs. He thought they should delay extensions until they were justified in carrying them out. There was the Clapham extension which had not been gone on with, why was that?

The **Chairman** pointed out that there was no object in moving an amendment, because that was a direct negative. It would be enough to vote against the motion.

Mr. Mocatta said that it had been stated that if the Bill were gone on with, it could be carried out by an independent company. It had also been stated that the great advantages to be derived in the future would not come to them unless the matter was taken in hand at once. Was it not advisable to take the step recommended while not committing themselves to anything, because others would carry out the Bill?

The **Chairman** was very sorry Mr. Middleton should take the view he did upon the subject. He could not help thinking that the wiser course was represented in what Mr. Mocatta had said. They were not going to propose to carry out the extension without the further assent of the shareholders. It was merely a question whether they would get the power. They could decide afterwards as to carrying it out. The Board thought the arrangements should be in the hands of that Company rather than that an independent party should come in and the Company have to make terms with them afterwards instead of they with the Company. Mr. Middleton asked why the Clapham extension had not been carried out. He thought it was all the more creditable to the Board that it had not been carried out, because they did not quite see until more perfect arrangements were made that the Clapham extension was going to add materially to the line. Having once again made a strong appeal to the shareholders to have confidence in the Board, he put the motion; the figures for which were announced as 26 in favour, and 5 against. The Chairman accordingly declared it carried.

Mr. Middleton demanded a poll, which was fixed for that day week (next Tuesday) at the office of the Company at 12 o'clock, the poll to remain open until 2 o'clock. Mr. James L. Oliver, of Newcastle, was nominated as scrutineer on behalf of Mr. Middleton, and Mr. Donald MacMillan for the Directors.

The proceedings then closed with a vote of thanks to the Chairman.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The half-yearly general meeting of this Company was held on Friday last at Winchester House, Mr. Francis A. Bevan presiding in the absence, through illness, of the Marquis of Tweeddale (the chairman of the Company).

The **Chairman** said he could quite understand that on reading the report there might have been a certain amount of disappointment at the result of the year's working. There had been scarcely any increase in the receipts, for he might explain that of the increase of £6,000 odd, about £4,000 was really a matter of account. There had been an increase in their expenses, but they had had to open new stations in order to meet the very powerful competition which they had to contend against, and they had had to spend rather more than usual upon cable repairs. He was glad to say that the new year had opened better. From the 1st to the 28th inst. there had been daily increases of £50 in their receipts, and if business became better there was no doubt that they would share in the good results that would ensue. A shareholder had suggested that they should increase the dividend by taking something from the renewal fund. It appeared, however, to the Directors that this would not be a wise proceeding. The renewal fund was the backbone of their Company. At the present time their Brest-St. Pierre cable was broken in deep water, something over 1,000 fathoms, and they were endeavouring to repair it. They could not say how much the repair would cost; they could not say even whether they could repair it, though probably they could. It would be most unwise, therefore, to whittle away, as he might call it, their renewal fund. They heard sometimes that they compared very unfavourably with their rival, the Commercial Company, but they had to pay on a very large capital as compared with their rivals, and therefore the comparison after all was not so unfavourable, taking also into account the further fact that the Commercial Company had two new cables, which did not require the repairs that old cables did, and that they had an enormous pull in their connections in America.

The motion was seconded by **Sir James Anderson** and carried after a discussion.

CENTRAL LONDON RAILWAY COMPANY.

The first ordinary general meeting of this Company was held at the offices, 30, St. Swithin's-lane, E.C, on Wednesday afternoon, the Chairman, Mr. F. A. Lucas, presiding.

The **Secretary**, Mr. Matesdorf, having read the notice convening the meeting,

The **Chairman** said he was not going to make a speech, as this was merely a formal meeting held in pursuance of the Act of Parliament. No shares had yet been issued to the public, and so that was practically a meeting of corporators. The only business was to re-elect the retiring directors, and he proposed that the following gentlemen be re-elected—viz., Messrs. De Crano, F. A. Lucas, H. Mosenthal and D. Parish.

This having been seconded, was carried unanimously.

The meeting then became special to consider and approve of the Bill promoted by the Company, which has been deposited in the House of Commons.

The **Chairman** called upon the solicitor, Mr. Morris, to explain the objects of the Bill. In doing this the **Solicitor** said that by the Act of 1891 the Central London Company, which was incorporated by that Act, was authorised to make a railway six miles in length from Shepherd's Bush to Cornhill. By the Bill then before the meeting it was proposed to abandon so much of the authorised railway as was in Cornhill, and instead of having a terminal station there, to continue the line up Threadneedle-street and Broad-street to the Liverpool Station of the Great Eastern Railway, with which, as well as with the station of the North London Railway at Broad-street, it would be connected by subways.

The **Chairman** moved the approval of the Bill, which was seconded by **Mr. Mosenthal**, and carried unanimously.

COMPANIES' REPORTS.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY.

BALANCE-SHEET, 31st DECEMBER, 1891.

Dr.	£	s.	d.	£	s.	d
Nominal capital—						
10,000 shares of £5 each	50,000	0	0			
Present issue, 5,000 shares of £5 each	25,000	0	0			
Issued and allotted—						
4,066 shares of £4 per share called up	16,264	0	0			
802 „ £3 „ „	2,406	0	0			
4,868	18,670	0	0			
Add calls paid in advance £1,332, less calls due 8th Jan., 1892, £550, and calls in arrear £100	682	0	0			
				19,352	0	0
Six per cent. mortgage debentures				15,600	0	0
Creditors—on sundry accounts				5,281	11	5
Profit and loss account—profit for year to date				1,006	8	7
				£40,640	0	0

Cr.	£	s.	d.	£	s.	d.
Capital expenditure to date—						
Buildings and plant	29,427	5	2			
Meters, transformers, etc.	4,159	17	1			
				33,587	2	3
Loose plants and tools				294	19	6
Office furniture				104	15	8
Preliminary and formation expenses				654	3	8
Stocks and work in progress				1,887	17	1
Debtors—on current supply	1,106	17	5			
„ sundry debtors	1,128	19	5			
				2,235	16	10
Cash at bankers on deposit, with interest	1,520	18	8			
Cash at bankers on current account	275	15	8			
„ in hand	78	10	8			
				1,875	5	0
				£40,640	0	0

PROFIT AND LOSS ACCOUNT, 31st DECEMBER, 1891

Dr.	£	s.	d.	£	s.	d.
Station charges—Salaries, wages, coal, water, and maintenance				1,982	10	6
Street charges—Salaries and maintenance				333	13	2
Rent, rates, taxes, and insurance				307	11	11
General charges—Office salaries, legal and accountancy charges, stationery, stamps, telegrams, etc.				385	16	1
Balance carried down				1,668	3	0
				£4,677	14	8
Interest on debentures	610	13	9			
„ on calls paid in advance	51	0	8			
				661	14	5
Balance carried down				1,006	8	7
				£1,668	3	0

Cr.	£	s.	d.	£	s.	d.
Current supply	4,300	13	7			
Public lamp supply	27	6	7			
				4,328	0	2
Apparatus rent				345	11	7
Profit on sale of lamps				4	2	11
				£4,677	14	8
Balance brought down, being gross profit for year				1,668	3	0
				£1,668	3	0
Balance brought down, being net profit for one year.				1,006	8	7

BUSINESS NOTES.

West India and Panama Telegraph Company.—The receipts for the half-month ended January 31 were £2,735, against £3,791.

Direct Spanish Telegraph Company.—The receipts for last month were £2,195, against £2,147 for January, 1891, showing an increase of £48.

Eastern Telegraph Company.—The receipts for January were £63 436, against £60,005 for the same period of 1891, showing an increase of £3,431.

Eastern Extension Telegraph Company.—The receipts for January amounted to £42,805, against £46,575 in the corresponding period, showing a decrease of £3,770.

City and South London Railway.—The receipts for the week ending Jan. 31 were £823, against £703 for the same period of last year, being an increase of £120. The total receipts for January show an increase of £320 over last year. As compared with the week ending Jan. 24th, last week's receipts show an increase of £11.

The Cuba Submarine Telegraph Company, after providing for the dividend on the preference shares, recommend a dividend on the ordinary shares at the rate of 8 per cent. per annum, tax free. The traffic receipts for January were £3 500, as compared with £2,439 in the corresponding period of last year, an increase £1,061.

Edison and Swan Company.—At a meeting of the Directors on 2nd inst., it was resolved that a payment on account of the dividend of the current year be made on the 89,261 shares, £3 paid, of 5s. 3d. per share; on the 5,000 fully-paid shares, allotted to the Edison Company, 8s. 9d. per share; on the 12,139 fully-paid shares, allotted to the Swan United Company, 7s. 8d. per share. The dividend warrants will be issued on the 22nd inst.

St. James's and Pall Mall Company—The poll on the question as to whether Mr. Egerton Clarke should be re-elected a director of this Company, which was taken last Tuesday at the Company's offices, resulted in his favour by a small majority. He therefore returns to the Board. The circumstances which led to his re-election being challenged were fully given in our report of the above Company's meeting, *vide* last week's *Electrical Engineer*.

Companies Registered during January.—The following electrical companies were registered during the past month:

Electric Fittings Hiring and Maintenance Company, Limited, £5 and £1 shares	£200,500
Elmore's American and Canadian Patent Copper Depositing Company, Limited, £2 shares	200,000
Reading Electric Supply Company, Limited, £5 shares	75,000

PROVISIONAL PATENTS, 1892.

JANUARY 18.

969. **An improved brake for electromotors or for machines driven by electromotors.** Henry Robert Low and Benjamin Creigh, 41, Beaconsfield-road, St. Margaret's, Twickenham, Middlesex.

982. **Improvements in or connected with the manufacture or production of chloride of zinc and alkaline sulphates, and of zinc and chlorine by electrolysis of solutions thereof.** Thomas Parker, Alfred Edward Robinson, and Charles Henry Parker, 47, Lincoln's-inn-fields, London.

JANUARY 19.

1038. **A new or improved manufacture of an exciting material for galvanic batteries.** Hugo Koller, 46, Lincoln's-inn-fields, London.

1041. **Improved means of generating electricity for buildings.** Sarah Jane Rolleson, 50, Goldhurst-terrace, South Hampstead, London.

1061. **Improvements in bleaching and disinfecting starch and fecula by electrolysis.** Eugène Hermite, 11, Wellington-street, Strand, London.

1096. **Improvements in electric signalling on trains.** Alexander Shiels, 70, Wellington-street, Glasgow.

JANUARY 20.

1125. **Improvements in or connected with the side and other lights of electric or other launches or vessels.** Kerbey Deveron Bowen, 57, Chancery-lane, London.

1141. **Improvements in dry electrical elements.** Cæsar Vogt, Temple-chambers, London.

1143. **Improvements connected with electric elevators and motors.** American Elevator Company, Incorporated, 55, Chancery-lane, London. (Otis Bros. and Co., United States.) (Complete specification.)

1145. **Improvements in the manufacture of siliceous insulating material for electrical and other purposes.** Henry Alford Walker, 433, Strand, London.

1147. **Improvements in telephones.** Henry Edward Newton, 6, Bream's-buildings, London. (Parnell Rubbidge, New South Wales.) (Complete specification.)

JANUARY 21.

1163. **Improvements in connection with the brushes of electric generators and motors.** James Young and Robert Simpson, 4, Moorfields, London.

1185. **Improvements in stopping and starting pendulum clocks by means of electricity; the same applies to double pendulum movement as used in electricity meters.** William Green, 11, Stormont-road, Lavender-hill, London.

1216. **Improvements in electric cut-outs.** Hugo Korton, 54, Fleet-street, London.

JANUARY 22.

1254. **The automatic electric intermittent illuminating sign or lamp.** Frederick James Jones, 21, Foregate-street, Chester.

1298. **An improved table for telegraph instruments.** Katie Vonbora Miller, 55, Chancery-lane, London.

1308. **Improvements connected with electric targets.** John Forrest Walters, 166, Fleet-street, London.

1313. **Improvements in electric motor cars.** Sidney Howe Short, 18, Buckingham-street, Strand, London. (Complete specification.)

JANUARY 23.

1337. **Improvements in brushholders for dynamo machines.** Joseph Platt Hall, 17, St. Ann's-square, Manchester.

1340. **Improvements in electrical switches and other apparatus for making and breaking contact.** Henry James Shedlock Heather, 2, Chancellor's-road, Hammersmith, London.

1375. **Improvements in indicating apparatus for high-tension circuits.** Bernard Mervyn Drake and John Marshall Gorham, 66, Victoria-street, Westminster, London.

1391. **Improvements relating to the coating of articles with a new metallic alloy by electro-deposition.** The London Metallurgical Company, Limited, and Sherard Osborn Cowper-Coles, 45, Southampton-buildings, London. (Complete specification.)

1396. **An automatic electric circuit breaker.** Anton Eichler, 4, South-street, Finsbury, London. (Complete specification.)

1402. **Improvements in heating by the electric arc, and in apparatus therefor.** Henry Howard, 24, Southampton-buildings, London.

JANUARY 25.

1426. **Improvements in electrical batteries.** Cresacre George Moor, 13, Market-street, Penistone.

1436. **Improvements in friction driving gear for dynamo-electric and other like machinery.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (Armand de Bovet, France.)

1459. **Apparatus for adjusting commutators of dynamo-electric machines and motors to varying speed.** William White, James Radcliffe, and Frederick William Cooke, 28, Southampton-buildings, London.

1464. **Improvements in holders or sockets for incandescent electric lamps.** Thomas Jenner, 77, Chancery-lane, London.

JANUARY 26.

1479. **An electrical signalling and braking apparatus specially applicable to railway trains.** Guy Hamilton and Ernest Cockburn Day, 2, Lugar-place, Kelvinside, Glasgow.

1484. **Improvements in and relating to secondary batteries.** Justus Bulkley Entz and William Alfred Phillips, 70, Market-street, Manchester. (Complete specification.)

1497. **Improvements in couplings for electric wires.** Alexander Shiels, 159, Coldharbour-lane, Camberwell, London.

1552. **Improvements in telephone transmitters.** Joseph Goffin, 45, Southampton-buildings, London.

1557. **Improvements in electromagnetic apparatus for producing a reciprocating motion and for supplying intermittent electric currents for that purpose.** Richard Threlfall, 45, Southampton-buildings, London. (Complete specification.)

1571. **An improved incandescent lamp.** Ernest Frenot and Georges Nouville, 46, Lincoln's-inn-fields, London. (Date applied for under Patents Act, 1883, Section 103, July 21, 1891, being date of application in France.)

1580. **An improved electric low-water alarm.** Stephen Martin Mathews, 53, Chancery-lane, London. (Complete specification.)

JANUARY 27.

1626. **An improvement or improvements in the holders or carriers of electrical incandescent or glow lamps.** *Richard George* Evered, 7, Staple-inn London.

1637. **Improvements in and connected with telephones.** George Lee Anders and Walther Köttgen, 55, Chancery-lane, London.

1641. **Improvements in electromotors for electrically-propelled vehicles.** Alexander Siemens, 28, Southampton-buildings, London.

1656. **Improvements in electric brakes.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (Armand de Bovet, France.)

JANUARY 28.

1666. **Improvements in electrically-operated means for preventing railway collisions.** George Coles, Bristol Bank-buildings, Bristol.

1682. **Improvements in electrical arc lamps.** Oliver Firth, Sunbridge-chambers, Bradford, Yorkshire.

1695. **Improvements in instruments for the measurement of electromotive forces.** Thomas Parker and William Armistead, The Electric Construction Corporation, Limited, Wolverhampton.

1734. **An improvement in electric compasses and course recorders.** Joseph von Peichl, 28, Southampton-buildings, London.

1737. **Improvements in electric clock mechanism.** Alfred Julius Boult, 323, High Holborn, London. (Frank Alexander Ellis, ——.)

JANUARY 29.

1748. **Improvements in dynamo-electric machines.** Eugen Conrady and George William Brown, 56, Low-street, Keighley, Yorkshire.

1752. **Improvements in microphones.** Gustav Binswanger, 71, Queen Victoria-street, London.

1786. **Improvements in or relating to tanning by electricity.** Raffaele Pinna, 323, High Holborn, London.

JANUARY 30.

1829. **A portable electric planing and polishing machine.** Malcolm Sutherland, Leven Shipyard, Dumbarton.

1852. **Improvements in apparatus for registering electric and other currents.** Henry Raison, 27, Martin's-lane, Cannon-street, London.

SPECIFICATIONS PUBLISHED

1891.

2518. **Electro-depositing.** Gibbings. 8d.
3426. **Brushes, etc., for electric machines.** Dowsing. 8d.
3553. **Electric railways.** Thompson. (Reed.) 8d.
3738. **Electrolysing and bleaching.** Marx. 8d.
3893. **Electrical cables.** Glover and Preece. 8d.
3957. **Measuring electricity.** Miller and Woods. 6d.
4120. **Electric incandescent lamps.** Fryer. 8d.
5003. **Incandescence electric lamps.** Johnson. (Mace.) 8d.
12985. **Electric railway signalling.** Annesley and others. 8d.
14386. **Electric motors.** Dymond. (Gutmann). 8d.
14702. **Secondary batteries.** Hauser. 8d.
16870. **Dynamo-electric machines.** Sutcliffe and Atkinson. 6d.
17614. **Electric wire couplings.** Shiels. 6d.
17731. **Electric motors.** Linders. 6d.
17732. **Electric motors.** Linders. 6d.
20604. **Electric motors.** Lake. (Stanley and another.) 8d.
20629. **Incandescent electric lamps.** Dorman and Smith. 6d.
20678. **Electric burglar alarms.** Pohl. 6d.
20840. **Dynamo-electric machines.** Nebel. 8d.
20913 **Electrically-propelled vehicles.** Dewey. 8d.
20924. **Electric fire engines.** Dewey. 8d.
20930. **Electrically-propelled vehicles.** Dewey. 8d.
21442. **Secondary batteries.** Lake. (Roberts.) 4d.
21448. **Incandescent lamps.** Pitt. (Böhm.) 6d.
21449. **Electrical switches.** Howard. 6d.
21565. **Microphone.** Redfern. (Deckert.) 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{1}{2}$
— Pref.	—	$2\frac{1}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	$19\frac{1}{2}$
House-to-House	5	5
Metropolitan Electric Supply	—	$9\frac{3}{8}$
London Electric Supply	5	$1\frac{1}{4}$
Swan United	$3\frac{1}{2}$	4
St. James'	—	$8\frac{3}{4}$
National Telephone	5	$4\frac{3}{8}$
Electric Construction	10	$6\frac{1}{4}$
Westminster Electric	—	7
Liverpool Electric Supply	5	5
	3	$2\frac{7}{8}$

NOTES.

The Telephone Bill.—Various local boards are joining together to oppose the National Telephone Company's Bill.

Lambeth.—The formal notice of the revocation of the Lambeth electric supply order has been received by the London County Council from the Board of Trade.

Chichester.—The Lighting Committee of Chichester are thinking of establishing a telephone line between the city and the water works pumping station at Fishbourne.

Bury.—At the Bury Town Council meeting last week the report of the General Purposes Committee upon electric lighting was brought forward, but further consideration was adjourned.

Aberdeen.—It is proposed to extend the tramways at Aberdeen for 1½ miles to the suburbs. Aberdeen should be informed of the work of Leeds in running suburban tramways by electricity.

Journalistic.—The two editors of the newly-established American *Electricity*, Mr. Herbert Laws Webb and Mr. George H. Guy, together with Mr. Paine, their business manager, have resigned.

New Zealand.—Messrs. Postlethwaite and Stephenson have purchased the going business of the New Zealand Engineering Company in Dunedin. Special attention is to be given to electrical engineering.

Swansea.—The speculative builder is not going to be behind the times. One contractor at Swansea is fitting up for electric light, inside and out, whole rows of middle-class houses he is building in the suburbs.

Birmingham.—The process of electric welding was explained and exhibited by Mr. A. Driver, engineer to the Small Arms Company, at the company's works, at a meeting of the Birmingham Mechanical Engineers.

Royal Meteorological Society.—A "Note on a Lightning Discharge at Thornbury, Gloucestershire, July 22nd, 1891," will be read by Ernest H. Cook, D.Sc., before the Royal Meteorological Society on Wednesday next.

Fulham.—The Fulham Vestry has affixed its seal to a petition against the application of the Putney and Hammersmith Electric Light and Power Supply Company for a provisional order to supply the district with electricity.

Gibraltar.—It will be remembered that some time ago Mr. W. H. Preece, F.R.S., was commissioned to report upon the lighting of Malta and Gibraltar for the Government. We learn that the lighting of Gibraltar has now been determined upon.

Cheltenham.—The surveyor of Cheltenham, finding that the cost of lighting the town destructor would be £70 for pipes and fittings alone, and that for less than that sum an efficient system of electric light could be provided, has fitted up the installation, which the Council have approved.

Liverpool Telephonic Dinner.—The second annual dinner of the Liverpool branch of the National Telephone Company's employés was held on Saturday, when 70 persons sat down to dinner, music, and speeches. The transmission of the remarks and music in this case was by ordinary old-fashioned sound vibrations.

Church Telephones in Glasgow.—The proposal of the National Telephone Company to establish a telephone service with St. George's Church, Glasgow, was referred to the Kirk Session for remarks, some members of the council observing it would be a distinct encouragement to non-attendance, and might influence the seat-letting.

Personal.—Mr. W. J. Hammer, the well-known electrical expert, who organised the Edison exhibit at the Paris Exhibition, is now in London, and is staying at the Hotel Savoy. For the past two years he has been carrying on a consulting practice, and is now visiting Europe in the interest of some of his clients in electrical matters.

Society of Arts.—The last of Prof. Forbes's lectures on "Electrical Distribution" will be given before the Society of Arts next Monday, dealing with generators of electricity by water power and by steam from destructors; account of destructors; hydraulic accumulator; utilisation of local circumstances; probable developments in the future.

Bermondsey. — At last week's meeting of the Bermondsey Vestry the General Purposes Committee reported that the surveyor had seen the engineer of the London Electric Supply Company, and found there was no difficulty in lighting the streets by electricity. The surveyor would bring up an estimate of the cost at the next meeting.

Blackburn.—The Blackburn Corporation are taking up the electric lighting question vigorously, and have commissioned Mr. Thomas Burton, electrical engineer, to map out a large central area for illumination with the electric light. The Corporation's parliamentary powers expire in August next, and it is intended to have at least 2,000 lights going before then.

Train Lighting.—An experimental train, consisting of new American buffet and drawing-room cars, was run on Tuesday over the South-Eastern line to Dover. The cars, which are very commodious, are luxuriously fitted and have all the latest improvements, including the electric light. It is understood that they will be run in connection with the continental service.

London School Board.—A recent meeting of the London School Board adopted a recommendation of their Works Committee to spend £3,600, exclusive of fittings, for an electric light installation for their enlarged offices. The committee find that the whole of the offices can be lighted by electricity for £550 a year, whereas even the present gas bill is over £600 a year.

Clerkenwell.—The Clerkenwell Vestry intend to offer no opposition to the application to the Board of Trade by the Brush Electrical Engineering Company, asking for an extension of time for making the deposit under the order of 1891 until one month after the confirmation, refusal, or withdrawal of the order now being applied for by the County of London Electric Lighting Company.

Dufftown.—A display of electric light has been given in Dufftown by Provost Symon in order to show the superiority of the electric light over gas, and so popularise the introduction of electricity into the town. A 2,000-c.p. lamp was supplied by a dynamo driven by a traction engine. At a meeting subsequently held it was almost unanimously resolved to introduce the electric light at once.

Coast Communication.—Amongst the notices of motions before the present Parliament is one for March 4 by Sir Edward Birkbeck to call attention to the loss of life and property on our coasts, and the necessity for improved telegraphic and telephonic communication. All the forces of naval, commercial, and electrical circles should be called up to give force to Sir Edward Birkbeck's motion.

Design of Dynamos.—A meeting of the Association of Birmingham Students of the Institution of Civil Engineers was held on Thursday evening at the Midland Institute, the president, Mr. J. Edward Willcox, A.M.I.C.E., being in the chair. A paper was read by Mr. T. Rooke,

Student Inst.C.E., "On the Design and Construction of Dynamos," which was followed by an interesting discussion.

Inverness.—The proposal to light Inverness by electricity has been abandoned for the present. At a meeting of the Town Council on Monday a motion was definitely adopted discharging the committee appointed to investigate the matter on the ground that the scheme would cost between £30,000 and £40,000. At the same meeting it was resolved to extend the gas works at an estimated cost of £9,800.

Electric Light and Fog.—A correspondent of the *Scotsman* points out, with reference to the wreck of the "Eider," that an electric beam can usually be seen at a far greater distance if sent vertically into the sky instead of horizontally. This was, we believe, found to be the case at the Naval Exhibition, and it would be interesting to have the combined experience of lighthouse engineers and seamen upon this increasingly-important subject.

Godalming.—The Godalming Electric Lighting Committee recommended at the last Town Council meeting that the sum of £25 be paid to Messrs. Day and Co. for charges and fees in connection with the electric lighting. Alderman Gammon (one of the committee) stated that the sum of 10 guineas was for getting up specifications for the town and for plant, and was an entirely separate item. The recommendation was unanimously adopted.

Lynton.—At the Lynton Local Board meeting last week a letter was read from Mr. Green stating that he had assigned all his rights in the electric works at Lynmouth to Mr. Benn. A petition was read, signed by most of the residents at Lynmouth, asking for a 2,000-c.p. arc light to be placed on the Tower for the benefit of the fishermen and the lighting of the Esplanade and lower part of Lynmouth. This was referred to the Lighting Committee.

City Meat Market.—At the meeting of the Commissioners of Sewers on Tuesday the clerk read a letter from the town clerk relative to a petition from Messrs. Julius Sax and Co. to light the central markets with the electric light, the Central Market Committee being anxious to know the position in which the Commissioners stood in regard to the present lighting arrangements. On the motion of Mr. Sayer, this letter was referred to the Streets Committee for consideration.

Gas.—One of our gas contemporaries throws out a challenge to the electrical press to give an opinion upon Colonel Makins's figures in his speech to the Gas Light and Coke Company. What would be the use of such an opinion even in conjunction with any statement of Mr. Preece's? What conclusion does our gas contemporary come to from these figures? Ours is favourable to the electric light, and there is no difficulty in stating why it is so; but first let us hear what gas says.

Torquay.—At the Torquay Town Council meeting last Friday, Mr. Harrison said that seeing they had spent £500 in acquiring powers for lighting the town by electricity, he thought they should proceed with the matter, as the compulsory powers would soon expire. The Board should get the advice of an expert. Dr. Richardson said the license giving compulsory powers would not expire until July, 1893, so that there was a year and a half to run. The Electric Light Committee were giving the matter consideration.

Marseilles.—A strike of a novel character has occurred at Marseilles. The inhabitants have long been complaining of the exorbitant charges of the gas company, and recently a league of the largest consumers has been formed. A notice has been sent in that after the 25th, if a reduction *is not made,* the league will use no more gas, and pending the introduction of the electric light many have laid in stocks of lamps and petroleum, and on Monday many of the establishments on the Cannebière were illuminated by oil lamps.

Electric Tramway for Perth. — At a special meeting of the Perth Police Commission last week, consent was given to the proposed provisional order authorising the construction of an electric tramway between Perth and New Scone on condition that the clauses as agreed to by the Commission be accepted by the promoters. The Commission ask £50 towards the cost, stipulate that operations be not commenced till two-thirds of the capital is subscribed, that the promoters pay £250 towards the cost of widening High-street if necessary, and pave between the rails on Perth Bridge.

London Railway Schemes.—The London County Council have decided to petition against the Baker-street and Waterloo Railway Bill, the Central London Railway Bill, the City and South London Railway Bill, the Great Northern and City Railway Bill, the Hampstead, St. Pancras, and Charing Cross Railway Bill, and the Waterloo and City Railway Blll, with a view to securing the insertion of clauses prohibiting the companies from bringing forward their buildings beyond the general line of frontage of buildings in streets; and also to obtain sewer, bridges, placard, or other necessary clauses.

Strikes.—Messrs. Ernest Scott and Mountain, Limited, Close Works, Newcastle-on-Tyne, are fortunate in being in full work during the present extensive strike on the Tyne, as their men remain at work in all departments. They, however, were the victims of a strike about a year ago of a very similar character to that now going on, and which arose from disputes between two classes of their foundrymen, resulting in the entire loss of employment to all the brassfounders in their works, the work being since then satisfactorily accomplished by men brought from other departments, against whose use in the brass works the brassfounders had struck.

Coloured Glasses.—It is seldom our pleasure to notice such an elaborately printed catalogue as that just issued by Messrs. Paterson and Cooper of electric globes, shades, and reflectors. Broad shades and narrow shades, plain, crinkled, twisted, convoluted, veined, and variously streaked and coloured—some scores of different patterns are beautifully represented in their actual colours; and, if we may believe the figures, there must be some thousands of different varieties. This is evidently a catalogue that no good electrical contractor can afford to be without, either to choose from himself or to charm the heart of the lady of the house he is wishing to light up. The shades can then be selected in perfect harmony with their other surroundings. For London customers, the shades themselves can be seen at the firm's West-end branch in Princes-mansions.

New Bahamas Cable. — Another link between England and one of the colonies has been completed by the successful termination on the 4th inst. of the laying of a cable by W. T. Henley's Telegraph Works Company between the Bahamas and Jupiter Inlet, on the coast of Florida. The Act authorising the construction of the cable was passed last session, and the contract for the manufacture and laying of it was made with the company, whose cable ship "Westmeath" left England at the end of December last. Congratulatory telegrams passed between the company and Sir Ambrose Shea, the governor of the Bahamas, expressing hope of the usefulness of the cable in binding together the colony and the mother country in close bonds of commercial intercourse and affection,

The return message said "Cable worked splendidly—contract most faithfully performed."

Paterson and Cooper—A Disclaimer.—Mr. W. B. Esson writes taking exception to the statement in our biographical note, that the extension of Paterson and Cooper's "work in various directions is due entirely to the energy and ability of the manager." "The success of the firm," he observes, "can be attributed to no particular individual, and it must not be forgotten that the partners themselves work most energetically in their respective departments. To run an electrical business successfully all concerned must work hard, and work together, and in this respect the firm of Paterson and Cooper is no exception." We scarcely think our note likely to be misunderstood, for it is well known that the principals of the firm have been most energetic in developing the several branches of their now extensive business.

British Association.—The meeting of the British Association at Edinburgh this year, under the presidency of Sir Archibald Geikie, is likely to be exceptionally well attended, for not only is the locality very attractive, but a very strong list of presidents of sections has been made. At its last meeting the council of the association was informed that the following had accepted nominations as presidents of sections: Section A, Prof. Schuster, F.R.S.; Section B, Prof. H. McLeod, F.R.S.; Section C, Prof. Lapworth, F.R.S.; Section D, Prof. W. Rutherford, F.R.S.; Section E, Prof. J. Geikie, F.R.S.; Section F, the Hon. Sir C. W. Freemantle, K.C.B.; Section G, Prof. W. C. Unwin, F.R.S.; Section H, Prof. A. Macalister, F.R.S. The Committee upon the Prehistoric Remains of the British Islands is continuing its work, and it is expected to present its report to the committee of Section H at Edinburgh.

Electric Vehicles.—The Parliamentary Committee of the London County Council report that the object of the Ward Electrical Car Company's Bill is to authorise the Ward Electrical Car Company, by agreement with local authorities, to use electrical carriages, and on being licensed, to ply for hire with them. This being the first application for licensing for hire electrical power, with the concurrence of the Highways Committee, they consider that the present opportunity should be taken for making the Council the licensing authority for the user of the cars, and that the licensing should not be left to the Home Office. As the Bill is at present framed, nothing can be done without the consent of the local authority. They recommended at the County Council meeting on Tuesday that the Bill should be amended so as to make the Council the licensing authority for plying for hire, and that a petition be presented against the Ward Electrical Car Company's Bill. This was agreed to.

Southend Pier.—The tramway at the Southend Pier seems to have had a satisfactory result in stimulating passengers to pay for rides, for we find last week at the Southend Local Board Mr. Wood proposing to extend the facilities. The Pier Committee reported that they had under consideration the question of the desirability of providing additional plant and rolling-stock, and recommended an engineer should be appointed to advise. The chairman opposed this report, as he thought with a little alteration the old tramcars might be utilised. He would advise them to first get a perfect system with the present arrangements, and then consider this further increase. Mr. Allen said they must have a duplicate engine, in case of a breakdown. Besides, they wanted more light, as they wanted to light the pier from one end to the other; which, when done, would make the fortunes of the watermen, who could row their fares round it. Mr. Pawley complained of the present cars. The recommendation was carried.

Liverpool.—At a meeting of the Watch Committee of the Liverpool Corporation on Monday, the question of the provisional order applied for by the Liverpool Electric Supply Company, Limited, was again under consideration. A letter was read from the solicitors of the company, Messrs. Ayrton, Radcliffe, and Wright, expressing willingness to negotiate on the terms suggested at the Council meeting for the purchase of the undertaking of a going concern any time after the year 1895, upon giving 12 months' notice to the company of their intention to do so, and on condition that the Corporation extend the ordinary time for the purchase under the terms of the Electric Lighting Act to 40 years instead of 21 years and 42 years respectively, as at present. After discussion it was resolved that the town clerk be authorised to communicate with the company on the subject. It is stated that the committee were willing to proceed with the negotiation to purchase, as a going concern, on the basis of the proposal submitted and at a fair valuation.

Reading.—The Reading Town Council last week had before them the report of the General Purposes Committee. In this report it was stated that the town clerk reminded the committee that the license proposed to be granted to the Laing, Wharton, and Down Construction Company, Limited, to supply electricity for lighting purposes within the borough had remained in abeyance for some time past, the Board of Trade having refused to allow the insertion in the license of a clause providing for the transfer thereof to a prospective company, and that in these circumstances a company had been in process of formation. The town clerk further submitted recent letters on the subject from Mr. H. F. Kite, the solicitor to the Laing, Wharton, and Down Construction Syndicate, Limited. It was resolved to recommend that the Council give consent to a license being granted to the Reading Electric Supply Company, Limited, subject to the form of the license being finally settled to the satisfaction of the town clerk, and being approved by the Council. The Council have decided to light the municipal buildings.

Hampstead and Charing Cross Railway.—The promoters of the proposed Hampstead, St. Pancras, and Charing Cross Railway scheme have deposited the parliamentary estimates for the construction of this railway, prepared by Sir Douglas Fox, C.E., and Mr. J. H. Greathead, C.E. The total cost of constructing this line, with all subsidiary works, is estimated at £1,255,815, of which £1,030,656 is for the main line, four miles four furlongs in length, from Charing Cross to High-street, Hampstead; £185,809 for the short line, six furlongs four chains in length, from under the Hampstead-road to the King's Cross Station of the Great Northern Railway; £7,150 for the subway under the Strand to connect with the Charing Cross Station of the South-Eastern Railway; and £2,200 for a bridge for foot passengers between St. Pancras and King's Cross Stations. The railway, if sanctioned, is proposed to be constructed in two separate tunnels, one for up and one for down traffic, and of the total cost, it is estimated that £729,860 will be expended in the actual tunnelling. The acquisition of land and buildings will, it is estimated, cost £240,000; the construction of stations, £107,100; and for general contingencies a sum of £118,170 is allowed.

Bradford.—The electric light station at Bradford has made a profit of nearly £1,000 during the last half-year. At the meeting of the Bradford Town Council on Tuesday, Alderman Priestman, chairman of the Gas and Electricity Committee, presented a detailed statement for the half-year ending Dec. 31st. He was pleased to be able to say that his anticipations a year since had been amply fulfilled.

For the supply of electricity the balance to net revenue account was £2,001. 14s. 6d. The net profit for the half-year was £971. 4s. 10d. The first half-year's loss was £1,079, the second £733, the third £315, and the fourth £30, being a total of £2,157. Thus, with the profit made during the past half-year, there had been only a loss of £1,186, after having paid interest on sinking fund from the very first day of borrowing money for the electric works. As to the cost of coal in the production of electricity, he said the average was 7s. 7d. per ton, or 1·258d. per Board of Trade unit, which was regarded as equal to from 1½ h.p. to 2 h.p. He believed that, as compared with what was done at other electric lighting stations, the works of the Corporation would be found to be most economical; and he believed that if they had to start again they would not be able to improve upon the system which had been adopted.

Glasgow.—At the meeting of the Glasgow Town Council on the 4th inst., the special committee on electric lighting recommended that the business, heritable property, plant, and machinery belonging to Messrs. Muir, Mavor, Coulson, and Co. should be acquired by the Corporation at the price of £15,000—the Corporation to receive possession on 1st March next. Mr. Mitchell moved the approval of the minutes. Mr. Bell, in seconding the motion, said that Messrs. Muir, Mavor, Coulson, and Co. some time ago offered their works at £30,000. The committee did not entertain the offer, but now, as it had been reduced to £15,000, the committee were unanimous in recommending that it should be accepted. Bailie James Martin wished to know what was included in the £15,000, and pointed out that when the time came for the Corporation to supply electric lighting, they would require to put the wires underground, and the overhead wires would have to be taken down. Mr. Bell said the committee appointed two commissioners to go over the works, and their valuation amounted to £13,000, without taking into account anything for the goodwill of the business. Seeing that they were only asking £15,000, the committee were unanimous in thinking that the business should be acquired. Mr. Alexander Murray asked the amount of the valuation of the overhead wires. Mr. Bell said he did not know that the overhead wires were separately valued, but the valuation would probably be £1,000 or £1,500. The minute was then approved.

Mains in Berkeley-square.—The Highways Committee of the London County Council report that they have considered a notice from the London Electric Supply Corporation of intention to lay distributing mains, consisting of concentric lead-covered cables drawn into cast-iron pipes, in Charles-street, Berkeley-square, and Chesterfield-street. Similar works having been approved by the Council on previous notices of this company, they recommend that the sanction of the Council be given to the works referred to in the notice upon condition that the company give two days' notice to the Council's chief engineer before commencing the works; that the mains be laid under the footways, and be kept 9in. below the under side of the paving wherever it is practicable to do so; that where the mains cross the carriageways they be kept at the same depth below the concrete or the road material, as the case may be; that the positions of the street boxes, and the mode of construction of them, shall be submitted to and approved by the Council's chief engineer; that all pipes or openings from or into the boxes shall be of such shape as to remove all risk of injury to the covering of the cables; that all cables crossing the boxes shall be supported from below in the boxes; that all service lines or small cables shall be protected, where leaving the boxes, by an extra lead covering or by wooden stoppers, and shall also have a copper wire of sufficient size carried from the service to the main cable, in good connection with the lead or iron outer casing; and that the ends of all mains terminating elsewhere than in a box shall be securely protected by iron caps, in addition to any other covering.

Waterloo Electric Railways.—The parliamentary estimates for the construction of the proposed railway from Waterloo to Baker-street have been prepared in accordance with the Standing Orders of the House of Commons. These estimates, which are signed by Messrs. Galbraith and Church, the engineers to the London and South-Western Railway Company, and Mr. J. H. Greathead, the engineer to the City and South London Railway, set down the total cost of constructing this line, including £32,000 for contingencies, at £990,000, or at the rate of just under £330,000 per mile, the total length of the proposed railway being three miles six chains. The cost of the actual tunnelling is estimated at £438,435, including the tunnel under the River Thames near Hungerford Bridge. The erection of the stations will absorb £189,500, whilst laying down the permanent way is estimated to cost £5,000 per mile. The railway for its entire length will be constructed underground. The parliamentary estimates for the construction of the proposed underground railway from near Waterloo Station to Mansion House-street have also been duly deposited by the promoters. These estimates set out the length of the line as one mile four furlongs 6·80 chains, and the total cost of construction at £499,769, or at the rate of about £333,178 per mile. Of this sum it is estimated that £144,300 will be required for the acquisition of land and buildings. The cost of tunnelling is set down at £208,615; of the erection of stations at £66,500; and for general contingencies a sum of £46,365 is allowed. These estimates are signed by the same engineers as the Baker-street and Waterloo railway scheme.

Thermo-Electric Stoves.—There seems to be something fatally "low," if one may so express it, about the vibrations of ordinary heat which prevents them from being used, except at several degrees of transformation, for the generation of electric currents. Notwithstanding Lord Rayleigh's *pronunciamento*, many investigators are hard at work at that most difficult and elusory problem of the present age, the direct generation of electricity from heat. Several recent attempts at advance in this field have come under our notice, and the direction of these seems to be at present more in the desire to utilise waste heat for the production of electricity as a by-product than in any direct attempt to force the heat vibrations to a higher scale on an efficient and economical footing. One of the recent ideas is the employment of the thermo-electric couples in a tubular form, each tube forming itself a Bunsen burner. The idea is clever, and the efficiency considerably higher than forms in which the white light of gas burners is used. A further development has been introduced by Dr. Giraud, of Chantilly, near Paris, who wishes to utilise the heat from an ordinary stove to furnish electric current as well. The products of combustion rise through an inner tube and descend the annular space between this and the walls of the stove. The heated gases are brought into contact with elements of nickelled and tinned iron and a zinc-antimony alloy, contained in stamped iron boxes. The capacity is given at 40 watts, the cost being about 1s. 3d. a unit, considering the total cost of coke. The idea may quite well be worth while being taken up tentatively by stovemakers, in conjunction with electrical engineers, for the utilisation of the waste heat in grates and stoves, and the study of these problems might lead to greater knowledge of the best arrangement for the use of heat on larger scales for the direct generation of electricity.

Town Lighting in Queensland.—We are able to report the immediate establishment of a central station at Rockhampton, Queensland, by the Rockhampton Gas and Coke Company, which has now an active electrical department. In November, 1889, this company procured an amended Act of Parliament from the Queensland Government to supply electricity for all public and private purposes within the municipality of Rockhampton and the borough of North Rockampton, including the bridge over the River Fitzroy that separates the two townships. The company have been carefully watching the growth of the electric supply companies in England, Europe, and Australasia, and a month or two ago issued a circular notifying customers of their intention to erect plant for supply at the rate of 1s. per unit, including meter rent, to see with what success the company would meet with if they put down a central station. This circular met with such success that the company decided to put down at once a plant for the supply of electricity. For this purpose they have since purchased a very central site in the busiest part of the town, and on this they will erect a central station. The method of distribution will be on three systems—viz., for 500 yards in each direction of the central station the system will be low tension (two wire) at 110 volts; beyond this area the system will be alternate-current transformers; and for the public street lighting (negotiations for which have been opened up with the Town Council), the system will be direct-current series arcs. The town is laid out on the block system, as in Melbourne, and the lamp columns for the arcs will be placed on refuges at the intersections of the various streets. A plant for 1,000 16-c.p. lamps for the low-tension, and 500 10-c.p. lamps for the alternate-current system will be put down at once. So far, 850 16-c.p. lamps have been taken up. The supply will begin about July next. The whole of the work has been planned out, and will be carried out under the supervision of Mr. A. E. Neal, the company's electrical engineer. The company will also carry out isolated installations in Queensland. Gas in Rockhampton is from 7s. 6d. to 12s. 6d. per 1,000ft., according to quantity consumed, or for lighting or heating, so that the company will have a good chance of successful competition with itself.

The Lighting of Larne.—A meeting of the residents of Larne was held on Thursday last week for the purpose of considering the question of the electric lighting of the town. The Commissioners adopted electric lighting on August 1 last, and their action has recently been called in question, with a result which has vindicated their progressive policy. Mr. John Fullerton, chairman of the Larne Town Commissioners, presided. Mr. Picken moved: "That the lighting of the public streets of Larne during the past six months has been imperfectly and insufficiently performed, in consequence of which the ratepayers and inhabitants have suffered serious inconvenience; and that the agreement entered into between the Larne Town Commissioners and J. E. H. Gordon and Co., Limited, London, has been effected without due regard to the interests of the ratepayers of Larne, who disapprove of the action of the Commissioners, particularly in attempting to concede to Messrs. Gordon and Co., Limited, the sole right of public and private lighting of the town by electricity for 42 years from 1891. That before entering into such an agreement the ratepayers should have been consulted, and their opinion taken in the matter." Mr. Thomas M'Cormick formally seconded the resolution. Mr. James Boyd moved the adoption of the following amendment, amid loud cheers: "1. That the ratepayers of Larne, in public meeting assembled, hereby express their great satisfaction with the public lighting by electricity of the principal streets of the town. 2. That they express no opinion (at present) in reference to the minor streets and suburbs, seeing that as soon after the new dynamo is in operation as possible, the contractors will replace the temporary lights now in use by more powerful ones, which it is expected will give every satisfaction. 3. That the agreement entered into between the Commissioners and the contractors, Messrs. Gordon and Co., being the usual one prescribed by the Board of Trade, is considered satisfactory, and that the Commissioners deserve the best thanks of the town for their enterprise and public spirit in introducing the electric light, and hereby have our confidence and support." Mr. John Bain seconded the amendment. Those who were not ratepayers were then asked to go upon the platform, and tellers having been appointed the chairman put the amendment, with the following result: For the amendment, 74; against, 48. The proceedings then terminated.

Burnley.—At the monthly meeting of the Burnley Town Council, on the 3rd inst., the Gas Committee reported that the question of electric lighting had been engaging their attention. When the provisional orders were granted in 1890, the Burnley Corporation followed the practice of other corporations, and adopted a waiting course, but action had now been forced upon them. The Co-operative Stores had intimated that if the Corporation did not take the matter in hand they would take steps to supply themselves, and the Tradesmen's Association had intimated that they also were prepared to do something in a similar direction. The term granted would expire at the end of August, and any outside company would be at liberty to come into the town and establish a central station. It was felt also that if application were made to the Board of Trade for an extension of time it might possibly be refused, as the Corporation had been inactive so long. A deputation from the committee accordingly went to London and gathered a good deal of useful information. They were convinced that the question of electric lighting had now passed the stage of experiment and that electricity would supply a steady, good, and reliable illuminant. Burnley was very favourably situated for laying down the installation. The land to be used for the station was close to the canal and the gas works, and the area to be supplied was exceedingly compact. In response to the circulars which had been sent out, promises representing 1,800 incandescent lamps of 16 c.p. had been received, and the committee considered that that was sufficiently encouraging to justify them in recommending the Council to sanction the calling in of a consulting electrical engineer. If his report was satisfactory, and he assured them that they could supply electricity at about double the price of gas, then the sanction of the Council would be asked to the work being proceeded with. It was proposed at first to provide sufficient power for 4,000 lamps, and the initial outlay of providing plant, building the house, laying the mains, etc., might be roughly placed at £20,000. It was very probable that the experiment would ultimately pay, but for the first year or two they could not expect to get much profit out of it. If it could be made to pay in other towns, surely it could be done in Burnley, which was so favourably situated. The electric light would greatly conduce to the health and comfort of those who had to work by the aid of gas light, and it would form an attraction to the town itself. Alderman Collings observed, in reference to this report, that when the committee had consulted with an electrical engineer they would be fully prepared to give further information.

THE CRYSTAL PALACE EXHIBITION.

At Stand 107, in the North Nave, **Messrs. Croggon and Co.**, of 16, Upper Thames-street, E.C., have a neatly arranged stand of electric fittings, bells, batteries, etc., and a model church tower, with a peal of tubular bells, which proves a great attraction to visitors. Our sketch gives a very good idea of the general appearance of Messrs. Croggon's stand and church. The latter is a model, 30ft. high, of St. Martin's, Guernsey, which the firm have fitted with their system of copper-tape lightning conductors, in the way shown on the model. Care is taken in fixing these conductors to connect all metal work with them. In the belfry is a peal of tubular bells, which are rung by means of current supplied from the Weymersch battery at an adjoining stand. The hammers are worked on the principle of single-stroke electric bells, from a keyboard. The electrical energy required to ring bells like these is very small. Messrs. Croggon state that those at the Palace can be rung with half an ampere, at a pressure of six volts. Country clergymen about to set up a peal of bells might do worse than adopt the tubular variety, with electrically-worked hammers. If the sexton proved obnoxious, the keyboard could be fitted up at the rectory, and the "last bell" timed to suit the parson's convenience.

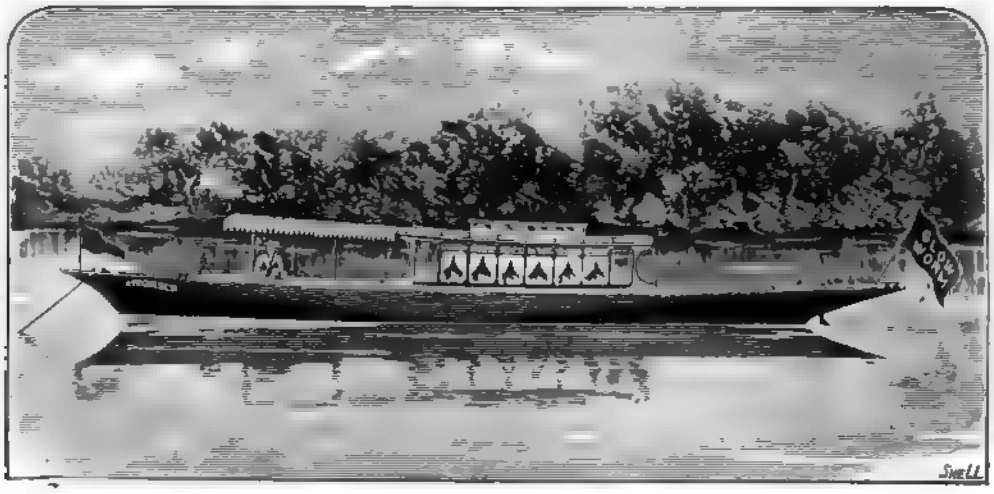
At their stand Messrs. Croggon show a large number of electric bells of all sizes, from the smallest house bell to one for factory use having a diameter of 12in. The firm have introduced a new contact pillar in their bells. This is cast on to its own base, and in this way the risk of shrinkage or shifting which sometimes occurs with the ordinary form of contact, and consequent failure of action, is obviated. Messrs. Croggon have supplied a number of their large bells, single-stroke and otherwise, to mines, factories, and large institutions such as asylums. The mining single-stroke bells, which are used to signal from the engine-room at the pit's mouth to the bottom of the shaft, are worked by an ordinary Morse key. A new design of bell, which obviates the necessity for a drop indicator where several bells are fitted up in one room, has two armatures, one of which is attached to a pendulum visible below the dome. When the bell is rung, the pendulum armature is attracted and suddenly released, causing the pendulum to vibrate for a minute or two, and so indicate the particular bell which has been rung. A new pattern ship's indicator is also shown. In a heavy seaway, ordinary drop indicators are apt to break loose by reason of the ship's motion. The

Sketch of Messrs. Croggon and Co.'s Stand at the Crystal Palace Exhibition.

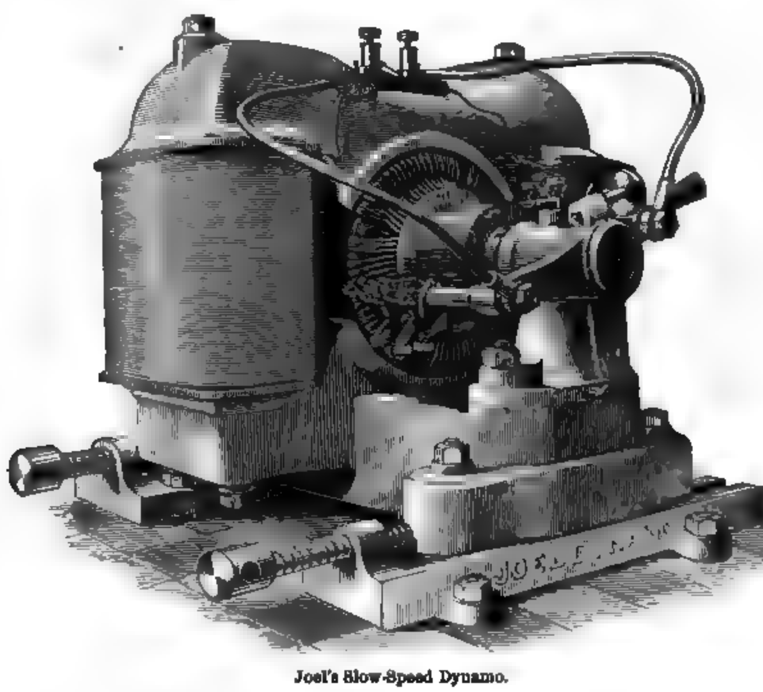
new one is so held by a catch on the armature that it can only fall when a current passes, no motion of the ship having any effect on it. For lifts, a useful indicator is provided which shows the liftman which floor has rung him up; while each floor is provided with an indicator which can be dropped by the man to show he has heard the call and is coming. Messrs. Croggon have brought out a new design of telephone which they sell outright at a very cheap rate, and which, when we tried it at their offices, certainly worked very well. Of the firm's specialities in the way of electric light fittings in wrought iron and copper, there are many elegant and pretty examples at the Palace. Their new pendant for electroliers or single lamps is very simple, and acts well. A ceiling rose contains a roller round which is wound the insulated leads. On pulling the cord a cam is released in the rose, and the roller unwinds until the action is stopped, when the cam engages again and holds the whole in position. The pendant works easily and with certainty. A new wall plug which we noticed on their stand is designed to do away with the objectionable projection noticeable in ordinary wall plugs, and which often leads to their being broken. In Croggon's plug this is obviated by having a push contact-piece at the top, so that the whole thing projects but little from the wall.

The firm have lately carried out several important contracts for wiring and fitting in private houses, as well as hotels and larger establishments, and report that they have their hands full at the present time.

Messrs. Woodhouse and Rawson, as we have previously stated, show, among other exhibits, a model of an electric launch. Many visitors stop and admire this elegant craft, which we understand was built by the Thames Electric and Steam Launch Company. Our readers will remember that Messrs. Woodhouse and Rawson have been particularly active in pushing the merits of electrical apparatus as applied to pleasure boats, and in conjunction with the Thames Company great energy is being put into the business. A rapid glance at the history of such boats is intimately connected with the name of Mr. W. S. Sargeant, who has recently established the company of which he is manager at Eel Pie Island. He designed and constructed the early floating and charging stations on the Thames. He also designed and built the well-known electric launch "Viscountess Bury," 65ft. 6in. by 10ft. 6in. beam, which has been running for the past three years on the Thames as a public pleasure-boat. The charging station at Eel Pie Island will consist of a 100-h.p. engine, transmitting power to two shunt-wound dynamos for charging accumulators. Suitable resistances are arranged that any E.M.F. between 100 and 300 volts, with an aggregate current of 200 amperes, can be obtained, which can be divided into 12 circuits by means of a switchboard. An ammeter can be put into any of the circuits by means of a switch, so that the energy supplied to customers can be measured and charged at a fixed rate. These dynamos will also transmit the current to the motors in the workshops, which will



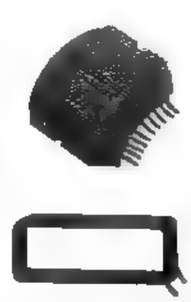
The Electric Launch "Glow Worm."



Joel's Slow-Speed Dynamo.

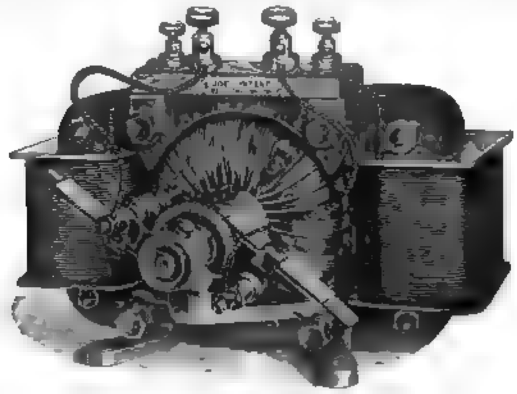
be used to drive the works' machine. Various suitable buildings are being erected for carrying on the business. Adjoining the works is The Island Hotel, and arrange ments have been made to light it throughout by electricity to be supplied from the works.

Joel's Armature and Commutator.



Segment of Coils.

We understand that Mr. Andrew Pears, (of soap fame) has given Mr. Sargeant another order. The new vessel is to be at the next Henley Regatta. She is designed especially for speed, and in appearance will somewhat resemble a torpedo-boat. This is the fourth order Mr. Sargeant has received from that gentleman. The first was the "Pioneer," an electrical launch designed and built by Mr. Sargeant to carry 20 passengers. She is 40ft. long with 5ft. 8in. beam, has a mean draught of 18in., and a displacement of 5¼ tons.



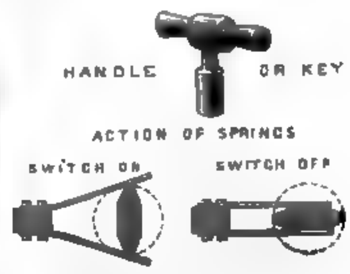
Joel's Motor.

The hull is constructed of three skins, the inner being diagonal, with outside planking longitudinally in narrow widths; the keel, which runs from stem to traffrail, is in one length of American rock elm. There is no dead wood aft; this has been entirely abandoned, thus giving a clear run and obtaining greater efficiency from the propeller. A speed of 8½ miles an hour will be obtained. The second order was the "Pilot," an electric launch designed as a sea-going pinnace, 26ft. 6in. by 5ft. 4in., and constructed to carry 15 people—draught aft 18in., and

Joel's Ammeter.

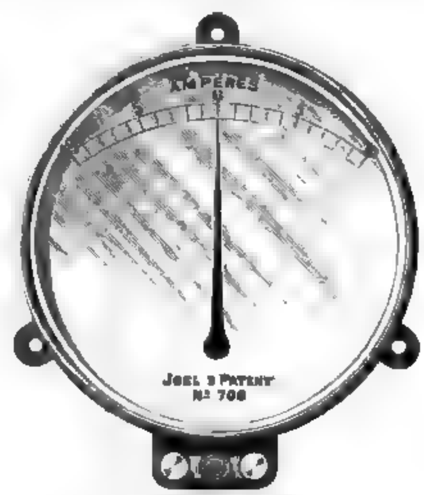
a displacement of 2¼ tons, speed eight miles an hour. The third order being the "Glowworm," which Mr. Sargeant also designed and moulded, together with the working model, now being exhibited on Messrs. Woodhouse and Rawson's stand at the Crystal Palace Exhibition, and which we illustrate herewith. The "Glowworm" is 53ft. long, with 7ft. 2in. beam, has a draught aft of 2ft. 6in., and displacement of 6¾ tons. The accumulators are placed under the seats, and the motor is aft, under the floor.

Joel's Main Switch.



Details of Joel's Main Switch.

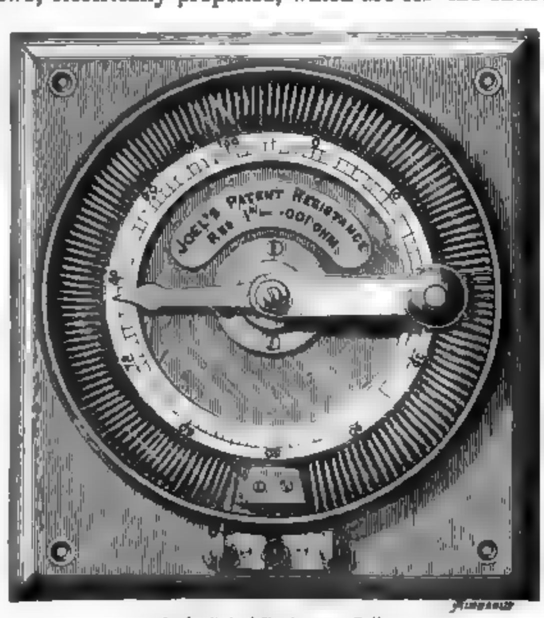
She carries 40 passengers, with a mean speed through the water of 9½ miles an hour, and is lighted as well as propelled by electricity. The potential is 126 volts, with a discharging current of about 35 amperes at full speed, the propeller rotating at 650 revolutions per



Joel's Engine Room Ammeter.

minute. The latter is connected direct with the armature shaft. This vessel has gained the reputation of being the fastest and handsomest electric launch on the Thames.

Amongst other launches in course of being laid down are two, electrically propelled, which are for the entire use



Joel's Spiral Resistance Coil.

of The Star and Garter Hotel, for pleasure parties during the summer months; they will be used for trips to Hampton Court Palace and back. There will be electrical communication between the hotel and the charging station at Eel

Pie Island, so that the launches can be alongside Messum's boat-raft in the time visitors are coming down from the hotel to the river. These launches will be 75ft. long with 13ft. beam, draught aft 3ft. 6in., built in three thicknesses of bright mahogany, with teak fittings throughout, a saloon deck the whole length of each vessel, fitted up with ladies' cabin, and for first and second-class passengers, refreshment bar, w.c.'s, pantries, and everything to meet the Board of Trade requirements; under whose survey they will be built. The saloon will be illuminated with incandescent lamps of 100 volts; port, starboard, and masthead lights will also be electric. The steering-wheel will be placed on the saloon deck amidships, so that the steersman has full view of the river. Alongside the wheel will be the switch, controlling the electrical power, which consists of one single lever, patented by Mr. Sargeant, and is arranged for full speed ahead, half speed ahead, full speed astern, half speed astern. The electrical power will be stored in the same way as the "Viscountess Bury." The accumulators are to be of the latest type in ebonite boxes, and will be supplied by the Electrical Power Storage Company, Limited. The pressure to be used will be 400 volts. The propeller will be connected up direct with

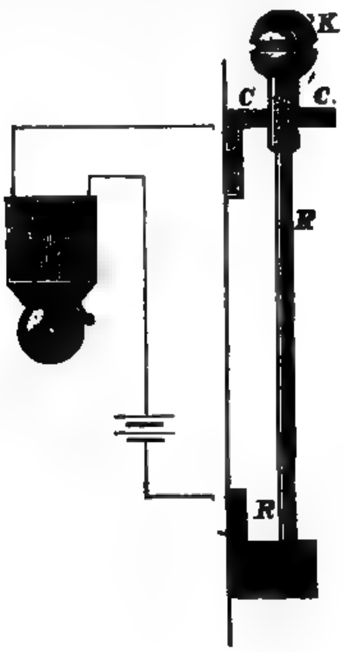


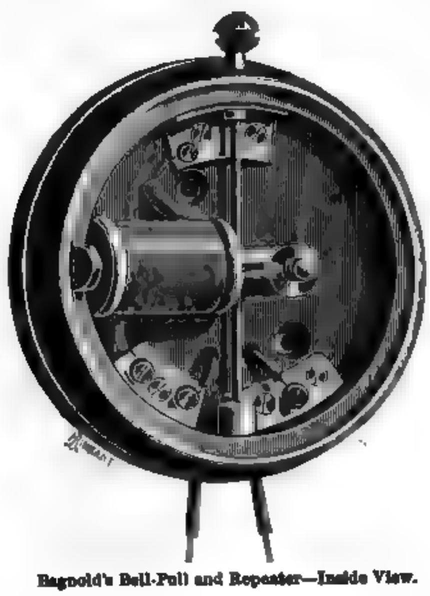
Diagram of Bagnold's Bell-Pull.

the armature shaft, and will rotate at 600 revolutions per minute. The lines of these vessels are calculated to give a speed through the water of eight knots, the displacement being 16½ tons. They will be running during the summer months from the new lock at Richmond to Teddington, between the hours of 10 a.m. and 8 p.m., calling at the following stations: Steamboat landing stage, Richmond; Messrs. Messum and Sons, the Pigeons and Club House, adjoining Buccleuch House (Sir J. Whittaker Ellis's residence), Eel Pie Island Hotel, Teddington Lock, and then returning.

The stand of **Messrs. Joel and Co.**, No. 157, in the North Nave, contains a good assortment of the apparatus manufactured by the company. The most conspicuous object is the dynamo, which, as it has often been described before, will require only a short description now. The illustration shows the newest type. The complete armature, is also shown in the figures, one representing the armature and commutator with segment of coils removed (showing pulley on end of axle), and the other representing segment of coils from armature and single armature coil. The armature is built up of sections or groups of laminated iron plates of segmental shape. These sections interlock, fit into each other, and are fastened by bolts to spokes, and thus form the rim of the wheel. The insulated wire coils are separately wound and are threaded on the core sections. The ends of the coils are connected in a special and convenient manner to the commutator, and can be quickly disconnected. The mechanical details are worked out to secure great simplicity, and to enable the dynamo to be easily and quickly taken to pieces and put together again without special skilled labour. This is useful on board ship, in the country, and other places where an easily repaired machine is necessary. For use on board ship a spare set of armature coils is provided, in the event of damage by steam, water, or any unavoidable cause, such as is frequently the case owing to the cramped space usually available for the electric light machinery; the engineers can then easily repair the machine and put in the new coils if necessary. The annexed illustration shows one of Joel's motors, being the result of many years of experiment and testing. They are made to run with either continuous or alternating currents.


Bagnold's Bell-Pull Without Cover.

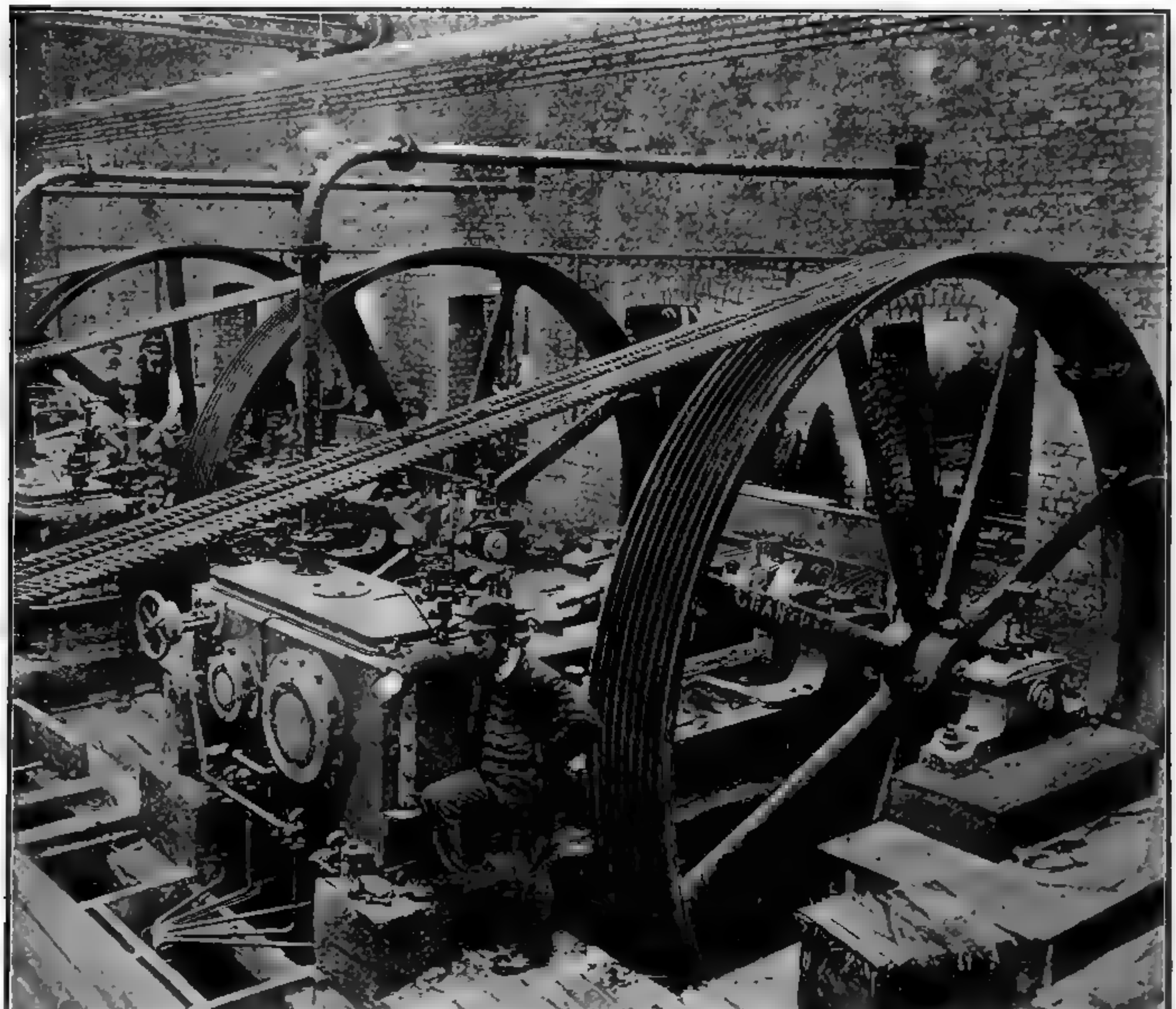
Hitherto, the want of such an alternating-current motor has been the great drawback to the extension of the alternating-current supply system, and it is considered that this motor will prove of immense importance in the future of electrical supply enterprises. The special feature of the motor is the use of very thin laminated iron in the fields and armature. The field magnet cores and poles are made in one piece of thin stampings of iron of the exact size and shape, and any number of these (according to the size required, are bolted together and thus make up the iron frame without any after tooling, and having the greatest possible magnetic efficiency. A number of these motors have been made and supplied, and are said to give an efficiency of 90 to 92 per.cent.


Bagnold's Bell-Pull and Repeater—Inside View.

Messrs. Joel and Co.'s patent main switches are made with porcelain backs and glass fronts with detachable key. We also illustrate these. The moving parts are completely closed in, and a key is needed for operating the switch. The contact bar is made of hard-rolled brass, and is slit so as to form a springy comb at the ends; the object being to make as many contact points as possible. These contacts pass under sparking shields fixed upon the terminal blocks. The switch has a double break; the sudden break being obtained by two flat steel springs, which press upon a stem of an elongated oval section, so that the springs are compressed when the switch is on and cause the contact bar to leave the terminals suddenly.

The makers claim that one of the special advantages of this type of switch is that it is completely protected from dust and interference, while its action can be readily observed through the glass case. Messrs. Joel and Co. also exhibit their patent ampere-meters, suitable for use with storage battery installations, as shown, and their central station engine-room ampere-meter, for use with arc lamp and continuous-current series circuits, and also their spiral resistance for adjusting circuits in central stations and many other purposes.

An improved bell-pull, which deserves to have a widely extended sale, if not to entirely supersede the "push-button," is shown on **Messrs. Siemens's** stand. For over 40 years the familiar push-button used in conjunction with electric bells has remained unaltered, except as regards the artistic design of its exterior, notwithstanding that considerable inconveniences are connected with the use of this simple household fitment. The ordinary push-button must be pressed in a direction at right angles to the surface of the wall or other support to which it is fixed. Again, the contact made is not always of the best; it is essentially a "butt" contact, and possesses little or no self-cleaning powers. When definitely established, say, in the immediate neighbourhood of a bed, or of an office or dinner-table, it is difficult to actuate these push-pieces from any other position. Pull-pieces have been devised, but these need to be pulled, as a rule, in one particular direction; flexible cord connections are also used, connected to "pear" pushes, but these again are seriously liable to derangement, and may be said to contain the elements of their own destruction. Generally speaking, there are many instances of daily occurrence in which the shifting of a bed, of an invalid's chair, or of a writing-table necessitates the advent of the electric bell-hanger and the moving of the contact-piece from one position in the room to another. In order to obviate these inconveniences, Messrs. Siemens Bros. and Co. are now supplying, under license from Major Bagnold, a simple and effective arrangement of bell-pull which, no matter where fixed in a room, can be easily actuated from any point in that room by attaching a thin cord, and leading this cord away in the desired direction; a very slight pull on the cord is necessary to make contact and ring the bell. In the diagram of the bell-pull and connections shown, an elastic rod of steel, R R, is set vertically with its lower end firmly fixed into a brass block, B; on its upper end is screwed a brass knob, K, the shank of which passes through a brass ring, C C, the conducting wires are attached to B and C. A slight pressure applied to K in almost any direction other than in that of the axis of the rod, R R, will deflect that rod, and cause the shank of the knob to touch the ring, C C, and make the necessary contact. This contact needs no silvering or platinising, as the knob can at any time be given a circular motion, which will clean the contact surfaces and ensure the establishment of the circuit. If it be desired to actuate this contact-piece from a distance, it is only necessary to tie a fine cord round the horizontal groove on knob, K, and this cord can be led off in any required direction, such as to a bed, a chair, or a dinner-table.



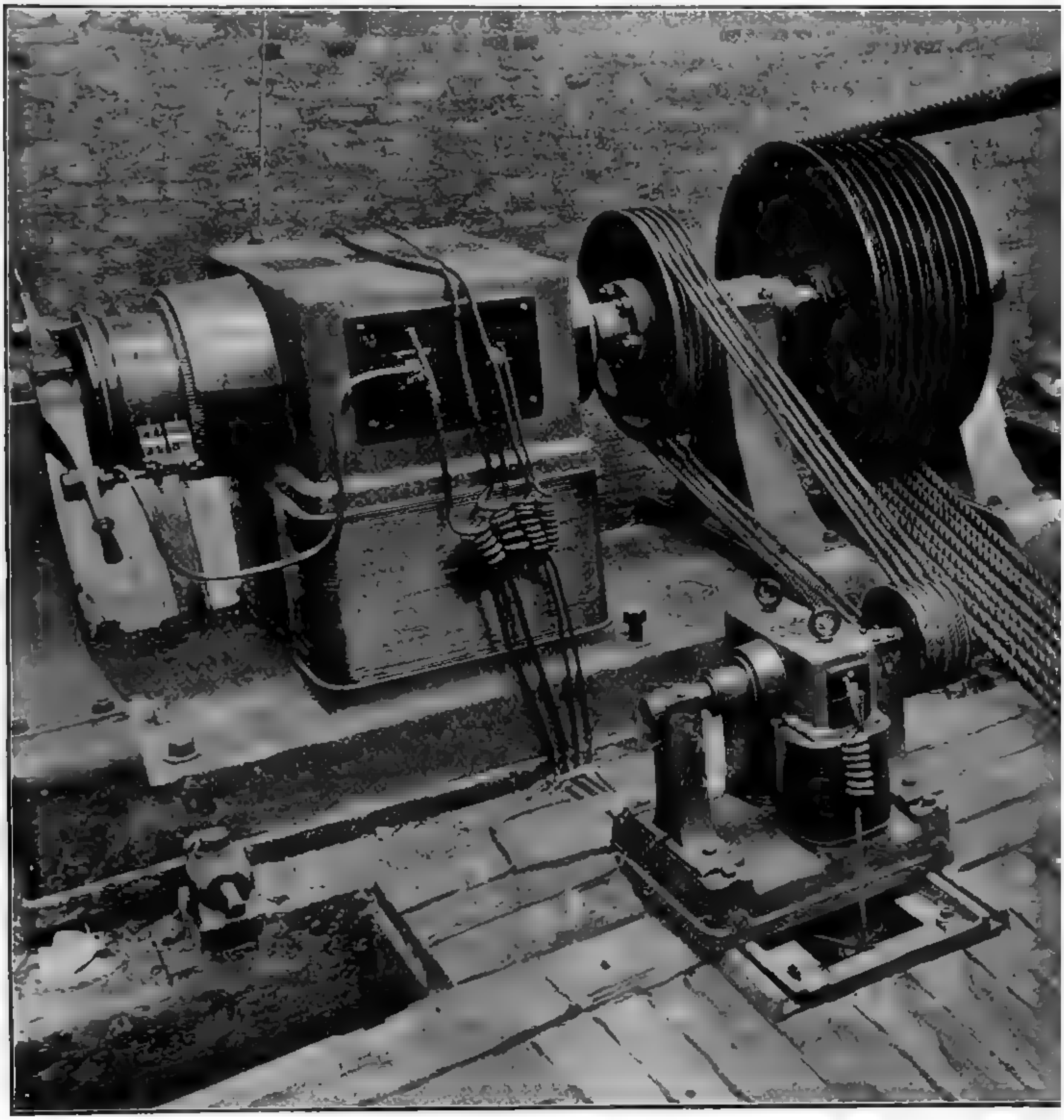
Engines at Sydenham Electric Light Station.

This bell-pull is made in various patterns and sizes. It can also be conveniently combined with a sound-repeater. When a bell-pull or push is actuated, it is often of great importance to be able to know that the electric bell is rung. The other illustrations show a new form of sound-repeater,

which, combined with the contact previously described, makes a most convenient and efficient fitting for this purpose. The repeater is shown both complete with the nickelled steel bell dome, and without the dome. When the latter is screwed on, one pole of the electromagnet is presented to the sound-boss of the bell; as soon as the contact is closed and the circuit is intermittently interrupted at the distant "chattering" bell the bell dome of the repeater is set into vibration, and gives out a clear ringing sound sufficient to indicate that the distant bell has acted, but not so loud as to be inconvenient to the occupants of the room in which the contact is made. The above-described system of ringing a steel bell magnetically can be applied in other ways. Thus, supposing it is desired to actuate several bells in series on one circuit, one of these can be an orderinary "chattering" bell and the others can be simply "sound-repeaters" without contacts. No difficulty of adjustment is experienced as in the case when ordinary chattering-bells are joined in series.

SYDENHAM ELECTRIC LIGHT STATION.

Continuing our illustrations of this station, we give this week views taken from photographs of the engines and dynamos. As we have previously said, the engines were built by Messrs. Hornsby and Sons, of Grantham; the dynamos at the works of the Electric Construction Corporation, Wolverhampton. These generators are each designed to give an output of 80 amperes at a pressure of 1,080 volts, with a speed of 370 revolutions per minute. The armatures are drum-wound. The magnets have a resistance of 9·5 ohms when hot, and are excited with a current of 14·2 amperes from a small machine driven by rope gear from a pulley keyed on the main shaft, as shown in the illustration. The generators themselves are also driven by rope gear, the pulleys being carried between two bearings. A coupling between pulley shaft and armature allows of the latter being removed without taking off the ropes. Each machine weighs 15 tons.



Alternator and Exciter at Sydenham Electric Light Station.

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LARNE.

It is the simple straw that tells which way the wind blows, and notwithstanding the immense efforts to keep the real wire-pullers in the background, some simple matter ofttimes enables us to trace home an attack upon the industry. We rather admire plucky combatants, but the man or men who are constantly trying a stab in the dark are neither worthy of sympathy nor commiseration. The attack of the gas interest upon electric lighting is scarcely or never straight. Puppets are put up and the wires pulled, the real organisers remaining in the background. We have no fault to find with gas for attacking electricity; rather it is the duty of those interested, but they might make an effort or two by means of pitched battles instead of lying in ambush. Distinctly, we do not believe in all the rubbish talked about gas not suffering from the introduction of electricity. It has got to suffer whatever may be said to the contrary, and the sooner the fact is recognised the better for all parties concerned. The coaching interest suffered from the introduction of steam. It is the natural law. Horses, indeed, were turned to other purposes, so may gas, and attention might well be directed to these other purposes. The *Larne Times* of Feb. 9 devotes almost an entire page to the report and consideration of a meeting of ratepayers, called to "give expression to the unsatisfactory lighting of the town; and also as to the forty-two years' agreement entered into between the Commissioners and Messrs. Gordon and Co." Immediately upon the result of the poll at this meeting being known, a voice was heard to say: "The gas promoters have lost the day"—hence the straw pointing to the real opponents of the electric light at Larne. The brief history of the whole matter may be given in a few words. As is well known, scores of local authorities have for years been off and on discussing the possibilities of electric lighting, and among others the Larne Commissioners. Messrs. Gordon and Co. have been very energetic in bringing plans for lighting before many authorities, and, again among others, before the Larne Commissioners. This activity succeeded in convincing the Commissioners that not only was such lighting practicable, but in this particular place compared favourably, as regards cost, with gas. As a result, the Commissioners entered into a three years' agreement with Messrs. Gordon and Co. The work of the installation was proceeded with, and as time was an object, temporary arrangements were made; the final permanent arrangements have yet to be finished. Here, then, was the chance of opponents. They laid hold of what they termed the unsatisfactory state of the lighting. Yet little stress was laid upon this at the meeting, while the fiercest battle raged round the "forty-two years' agreement," which is non-existent. Mr. Picken, a dissentient commissioner, was the leader of the opposing faction. He undoubtedly is a brave man. His audience was hostile, yet he put forward his case, reminding us of him whom Horace describes in the lines:

Si fractus illabatur orbis,
Impavidum ferient ruinæ.

In the end, the opponents of the electric light were beaten by seventy-four votes to forty-eight, and we trust the contractors will now go on their way undisturbed, complete the permanent apparatus, and by its success induce the ratepayers to go in for what one described is very much wanted—more light.

We are glad to find that Mr. Fullerton, the chairman of the Commission, condemned without qualification the argument that so crudely was the agreement drawn that it contained no clause to prevent the contractors going away and leaving the town in utter darkness. Electrical engineers will probably agree that the difficulty is in getting a foothold, and that after having invested eight or ten thousand pounds to put down an installation, there is little likelihood of abandoning the work. Before entering upon a contract, it may be assumed that the engineers carefully considered the probable income, and did not enter into a binding agreement till they were certain of their position. Opponents seem to consider that our Cromptons, our Gordons, and the managers of various firms and companies are not business men. We can assure them that few keener business men will be found in any industry than those who are now the ruling spirits in electrical engineering. It must be remembered, too, that it would not pay a firm of any repute to put its hand to the plough and afterwards turn back.

CANTOR LECTURE—No. 3.

Prof. Forbes at the commencement of his third lecture spoke in terms of great praise of Mr. Tesla's recent lecture, and took the opportunity of having a fling at some technical journal which had incurred his censure on the question of the practical man *versus* the scientific. It has been our misfortune to occasionally have a tilt at the arrogance and conceit of some so-called scientific men, but in this case we do not plead guilty, yet it may be assumed the guilty party will have little difficulty in combating Prof. Forbes's views. Mr. Tesla starts as a practical man, with a definite, practical end in view, and this distinguishes him, and others like him, from the inane dandy who experiments with the object of finding out something somehow. One millionth of such investigations prove useful to mankind—the rest are waste labour. Mr. Tesla's aim is, if we read him aright, to give us artificial sunlight—it may be a less powerful light, but softer, and as diffused over those areas in which the influence is at work. Passing from Mr. Tesla's work and the practical man, Prof. Forbes agreed upon the great value of oil as an insulator. The late David Brooks was the apostle of this system. For twelve or fifteen years before his death we held constant communication with him on the subject. Oil has always seemed to us the ideal insulator, and we regret Brooks is no longer among us to see that at length his views are becoming more common. The lecturer passed in review the necessity of so designing stations that big engines should not be running to waste, but rather, while obtaining economical engines, multiplying them and bringing them into use as the load comes on. He pointed out the difference between distribution of power and distribution of light, and, although we do not agree with all his conclusions, it must be admitted that a great difference exists. The lecturer concluded with a brief examination of the rotary-current system, and reference was made to recent experiments carried out with the apparatus now in London.

MR. TESLA AND VIBRATORY CURRENTS.

The lecture given by Mr. Tesla on Wednesday last week before the Institution of Electrical Engineers, and repeated on the Thursday before the Royal Institution, will live long in the imagination of every person in the brilliant scientific audiences that heard him, opening as it did, to many of them for the first time, apparently limitless possibilities in the applications and control of electricity. Seldom has there been such a gathering of all the foremost electrical authorities of the day, on the tiptoe of expectation to witness the experiments, details of some of which had already been given to us from the other side of the Atlantic, but of which no written account could convey the true significance and beauty. Long before the hour of meeting the hall was crowded, and Mr. Tesla was watched throughout with the keenest interest as he adjusted his apparatus quivering with lightning-like discharges, and now lighted a vacuum tube by grasping it in his hand, now brought to incandescence the filament of an ordinary lamp attached by a single wire, there rendering the air in the interior of a large ring luminous with flame, or sending streams of light from wires stretched over the audience, and, most fascinating of all, after electrifying the whole space of air between his table and an iron plate above him, waving a luminous tube in his hand totally unconnected to any wire whatever. It was, indeed, curious to see the most prominent and noted electricians of the day as interested in Mr. Tesla and his experiments as any child with the first friction machine, asking whether it was safe to do this or that, to touch the wires, and whether they might be allowed to try. For full two hours Mr. Tesla kept his audience spellbound, with easy confidence and the most modest manner possible displaying his experiments, and suggesting, one after another, outlooks for the practical application of his researches; and it was difficult to realise that this memorable lecture was the second only that he had ever delivered. Even at the end Mr. Tesla tantalisingly informed his listeners that he had shown them but one-third of what he was prepared to do, and the whole audience, after Prof. Ayrton had proposed the vote of congratulation and declared the meeting over, yet remained in their seats unwilling to disperse, insisting upon more, and Mr. Tesla had to deliver a supplementary lecture.

It is not for us here to describe the lecture in its details, as a full and illustrated report, revised by Mr. Tesla, is being prepared for the *Journal* of the Institution of Electrical Engineers, which will appear in due time, and containing much even that could only be glanced at in the lecture itself, and this will be the proper material for electrical engineers to fully discuss. But it may be allowed us to dwell a little upon the scientific *modus operandi*, and give certain particulars which our readers, no doubt, are looking for with interest.

In the first place, it may be stated, as Mr. Tesla mentioned, but which hardly seems to be realised, that practically the whole of the experiments shown were new, and had never been shown before, and were not merely a repetition of those given in his lecture in America. That of lighting tubes in an electrostatic field and of bringing filaments to incandescence on a single wire were shown before, and being of the most importance, naturally were not left out. But all the other experiments, together with most of the apparatus itself, was novel, and was supplementary to that of his American lecture.

In the next place, it is important to understand—as also stated by Mr. Tesla at the time, but hardly, perhaps, yet

realised—that nearly the whole of his experiments and effects were produced by means of an ordinary alternating current from an ordinary commercial alternating-current dynamo—such, in fact, as can, in many places, be obtained from a central supply company's mains. These effects can be, and were, brought about also by means of the currents from his special alternator, but the chief benefit of the use of this alternator is in being able to obtain perfectly harmonious currents of a known number of alternations per second, and in research work this knowledge is evidently of immense value.

Without going deeply into the detail or the theory of the working of the apparatus used, it is seen, therefore, that the effects are produced by using an alternating current, either generated direct at high potential and with high frequency of reversal per second, or ordinary currents converted into such currents. Mr. Tesla termed these currents "alternating currents of high potential and high frequency," but in the same way that the term rotary current (first proposed, we believe, in these columns) has now gained acceptance to indicate alternating currents varying in phase for producing a rotating magnetic field, so we may, perhaps, venture to use the term "vibratory currents" for those of high potential and high frequency. To generate vibratory currents from an ordinary alternating-current circuit, Mr. Tesla uses first an ordinary transformer in oil to transform upwards; the secondary current from this he passes into a second transformer having in its circuit a magnetic spark interrupter, and from the secondary circuit of this second transformer (which it may be noted is of comparatively thick short wire) he obtains discharges in all respects similar to those of the great induction coils, but of very high frequency. Connecting this circuit to a properly-adjusted condenser, in his case a set of Leyden jars, a surging effect is produced on the currents, which raises the frequency of vibrations from 25,000 or so per second to some millions per second, and the potential to some hundreds of thousands, or even, perhaps, millions of volts. The frequency in the case of the use of the Tesla dynamo can of course be accurately determined. The potential, it seems, cannot be accurately arrived at by calculation, or, rather, the calculation does not give an accurate result correspondent with the actualities achieved in these effects—a fact, as we shall see, that may have very important theoretical results upon the wave theory of electricity.

Having at command a vibratory current of this nature, the results shown by Mr. Tesla were the first outcome of continued and careful experiments. Not only does the molecular bombardment of the molecules of highly-exhausted gases in vacuum tubes show phosphorescence, but gases at low states of exhaustion do the same, and even ordinary air at ordinary temperature, as Mr. Tesla showed at his lecture, where the space between two concentric rings glowed with discharge like a vacuum tube itself, while the vacuum tube glowed when at some considerable distance from the plates to which the two poles were connected. In this manner, by vibrating the air molecules at speed correspondent to that of the vibration of light, phosphorescent effects could be shown with ease. Phosphorescence, Mr. Tesla explained, he regarded as incandescence in another form. Ordinary incandescence accrues after the filament has passed interiorly from the state of cold to that of intense heat; while if we regard a bombardment of molecules with sufficient intensity upon the surface of a material, we may conceive an infinitesimal film of that material rendered continuously incandescencent without the trouble of heating the whole—in a word, we obtain the light vibrations without passing through the whole gamut of heat vibrations—which has long been the electrical engineer's most ardent desire. To obtain a concrete idea of the difference between the ordinary alternating current and the vibratory current, we might imagine the first as a large ordinary steam engine reciprocating at 100 revolutions, while the second becomes a smaller and smaller material engine as its reciprocations mount from hundreds to thousands, or hundreds of thousands, in the same unit of time. In the latter we have the greatest efficiency with the smallest of first outlay.

We need not go further into the detail of the experiments shown by Mr. Tesla based upon these considerations, as they will be given, as we have said, fully in his paper. We merely mention here that Mr. Tesla hinted at illumination of houses without wires, transmission of light and power to a distance without wires, the synchronising of various wave-lengths for multiplex telegraphy without wires, the use of motors with but one wire, or even possibly without any, and the recovery of the solar energy radiated around us direct—"gearing," as he said, "our motors to Nature's wheels."

He demonstrated that our ideas upon dielectrics required modification, and that it was a mere question of potential to make every material or gas a conductor. It was shown that the interposition of a plate of ebonite, in fact, facilitated, rather than otherwise, the discharge. He showed that the vanes of the Crookes radiometer would rotate under the influence of his vibratory current, a rotation, curiously enough, the reverse way to that induced by light. We believe a similar result was first pointed out in a paper read before the Institution at Edinburgh by Mr. A. R. Bennett.

Mr. Tesla incidentally showed that the glow discharge in a tube under certain conditions would revolve and then become extremely susceptible to the feeblest magnetism, and he hinted that possibly by this means the rapidity of transmission of telegrams through submarine cables might be greatly increased.

A word remains about one or two personal and scientific problems. In the first place, it will be interesting to know Mr. Tesla's own ideas as to the future practicability of his researches—ideas which, of course, will have to await their fulfilment for some time for actual application in practice. The question naturally arises, How can the vibratory current be applied to lighting? Should we expect to have incandescent or phosphorescent lamps of a pattern similar to those we know in the Edison-Swan lamps or the Geissler tubes, or should we expect rather to discover a practical means for rendering the whole mass of the air in a room softly and beautifully phosphorescent? Both, Mr. Tesla thinks, if we understand him aright, may occur, but he looks certainly to the possibility of the last and most fascinating project. Further, many of those who witnessed his experiments must have asked themselves a question as to the danger of the vibratory currents, which Mr. Tesla handled so unconcernedly. We took an opportunity of enquiring of Mr. Tesla with reference to this point, how, indeed, he came to dare to take the current through his body? It was the result of a long debate in his mind, it appears, that caused him to attempt the experiment. Reason and calculation showed him that such currents ought not to be dangerous to life any more than the vibrations of light are dangerous. The self-induction and frequency of alternation should be too great for any current to pass, and for a current to be dangerous a certain quantity must pass. Conceive a thin diaphragm in a water-pipe, with to and fro piston-strokes of considerable amplitude the diaphragm will be ruptured at once. With reduced strokes of the same total energy the diaphragm will be less liable to rupture, until with a vibratory impulse of many thousands per second no actual current flows, and the diaphragm is in no danger of rupture. So with the vibratory current—yet in spite of reason and analogy it was with the feelings of a man about to plunge from Brooklyn Bridge (as one might well believe) that Mr. Tesla took his first shock from his apparatus. The result justified his daring, and he suffered no more than a slight shaking in the arms. A spark, of course, passes and this punctures the skin and causes a slight burn, but that is all. This can easily be avoided by holding a conductor of suitable size in the hand and receiving the shock upon that.

There lurks in one sentence of Mr. Tesla's lecture a statement which will cause much discussion in high scientific circles. We shall not further refer to it here than to say, that if the voltage obtained is not exactly calculable from the data laid down of the condenser and the frequencies—if, in a word, the result is not approximately that calculated, but considerably lower, then this would certainly seem to show that Hertz's experiments and results are not final, and the

way is open to further experiments and research in this direction.

From the way in which Mr. Tesla alluded feelingly to the impulse in research given to himself from perusal of Crookes's experiments in high vacuum, the effect upon students and scientific men generally of the publication of his own promising researches must be great. We can only hope that others, now that the way has been shown, will take up the work, and before many years have passed produce for the world at large the thoroughly practical outcome hinted at in the "wonder-full" lecture by Mr. Tesla at the Royal Institution, on Wednesday, the 3rd of February, 1892.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

III.

(Continued from page 67.)

Measurement of Electrical Resistance.

Resistance.—The retarding influence exercised by any substance to the free passage of an electric current is technically known as Electrical Resistance. Speaking generally, if the sectional area of any homogeneous metallic conductor is uniform, then its resistance is proportional to its length, provided its temperature does not vary; and further, if its length remains constant, then its resistance varies inversely as its sectional area, the temperature again remaining constant. As a rule, if a metallic conductor is heated its resistance increases. This is true of all the best-known conducting substances with the notable exception of carbon, whose resistance decreases as its temperature rises.

The reverse property to Resistance is called Conductivity, the conductivity of any conductor being a measure of the freedom which it affords to the passage of an electric current. Thus the greater the resistance of a conductor the less is its conductivity, and *vice versâ*.

Absolute electrical non-conductivity—that is, infinite resistance—is unattainable, and similarly, perfect electrical conductivity, or absence of resistance, is unknown. If all known substances were to be arranged in order of their conductivities, we would find the metals headed by silver and copper at the top of this list; carbon, graphite, and some solutions of salts and dilute acids, about the middle; and such substances as guttapercha, shellac, and dry air, at the bottom.

In the following table, chiefly due to Culley, there is given a list of the more important substances arranged according to this plan. Culley has further divided his substances into three classes: conductors, semi-conductors, and non-conductors or insulators; but this division is of course entirely arbitrary.

Table 2.—*List of Substances arranged in order of their Electrical Conductivities* (Culley).

Good Conductors.	*Semi-Conductors.*	*Insulators.*
Silver	Carbon	Wool
Copper	Graphite	Silk
Gold	Acids	Sealing Wax
Aluminium	Saline Solutions	Sulphur
Zinc	Sea Water	Resin
Platinum	Melting Ice	Guttapercha
Iron	Pure Water	Indiarubber
Tin	Stone	Shellac
Lead	Dry Ice	Paraffin
German Silver	Dry Wood	Vulcanite
Antimony	Porcelain	Glass
Mercury	Dry Paper	Dry Air

If a material is required which will carry an electric current with as little resistance as possible, it would be chosen from as near the top of this list as is compatible with cost of material, suitability for the special work, and various other conditions which will readily suggest themselves; and similarly, a body which is to act as an insulator would be chosen from near the bottom.

As a result of the foregoing considerations, the laws governing the electrical resistance of all metallic bodies may be stated as follows:

1. The total resistance of a uniform metallic conductor at any fixed temperature is directly proportional to its length, if its sectional area remains constant.

2. The total resistance of a uniform metallic conductor at any fixed temperature is inversely proportional to the area of its cross-section, if its length remains constant.

3. The total resistance of a uniform metallic conductor of any given length and cross-section at any fixed temperature is directly proportional to the specific resistance, and inversely proportional to the conductivity (taken at that temperature) of the material of which it is composed.

Specific resistances are usually expressed as the resistance in ohms, or microhms, of a cubic centimetre of the material, at 0° C. or 32° F. Specific electrical conductivity is the reciprocal of specific resistance.

If R represents the total resistance of the conductor in ohms,
r „ its specific resistance, or the resistance in ohms, of a cubic centimetre of the material,
L „ its length in centimetres,
and A „ its sectional area in square centimetres;

$$\text{then } R = \frac{r\,L}{A}.$$

Electrical resistances, however, are not usually obtained in this way, but by comparison with other conductors of known resistance (such as graduated coils of German silver, platinoid, etc., suitably mounted in a resistance-box) by one or other of the methods to be described later.

In the course of these articles constant reference will be made to specific or comparative resistance, conductivity, and insulating properties, of the various materials employed in the manufacture of electrical instruments, or of the substances for the determination of whose characteristics, delicate measuring instruments are employed. The following table, compiled from Dr. Matthiessen's experiments, gives a list of the more important conducting materials, in column 1; their specific electrical resistances in B.A. microhms (one microhm equals one-millionth of an ohm), in column 2; their approximate comparative resistances, taking the resistance of annealed silver as unity, in column 3; and their approximate percentage increase of resistance per degree centigrade increase of temperature, in column 4.

Table 3.—Resistances of Metals and Alloys at 0° C. (Matthiessen.)

Name of Metal.	Specific Resistance.	Comparative Resistance.	Percentage Increase of Resistance per deg. Cent
	B.A. Microhms.		Per cent.
Silver, annealed	1·521	1·00	0·377
„ hard-drawn	1·652	1·09	„
Copper, annealed	1·616	1·06	0·388
„ hard-drawn	1·652	1·09	„
Gold, annealed	2·081	1·38	0·365
„ hard-drawn	2·118	1·39	„
Aluminium, annealed	2·945	1·94	„
Zinc, pressed	5·689	3·75	„
Platinum, annealed	9·158	6·08	„
Iron „	9·825	6·80	„
Nickel „	12·60	8·30	„
Tin, pressed	13·36	8·80	„
Lead, pressed	19·85	13·60	0·387
Antimony, pressed	35·90	23·65	0·389
Bismuth „	132·7	87·20	0·354
Mercury, liquid	96·19	62·50	0·072
1 platinum + 2 silver, alloy	24·66	16·10	0·031
German silver, alloy	21·17	14·87	0·044
2 gold + 1 silver, alloy	10·99	7·22	0·065

(To be continued.)

INSTRUCTIONS FOR WORKING CROSSLEY'S "OTTO" GAS ENGINES (NEW TYPE).

(Extract from "First Principles of Electric Lighting.")

These engines are a great improvement on the slide-valve type, but at the same time it is necessary, for their safe management, that careful attention be paid to the instructions herein given.

The new ignition apparatus supplies the long-felt want of a reliable hot-tube ignition, and when kept in fairly good order and the instructions strictly adhered to, it is free from danger to the attendant.

Before Starting.—See that all the bearings and working parts are perfectly cleaned and well oiled, and that water is supplied to the cylinder-jacket.

Next, move the ignition-valve in and out by hand to make sure it is not sticking.

Starting.—1. The gas flame in the chimney should be lighted *ten minutes* before the engine is required to work. See that the flame does not light back and burn at the air-holes in Bunsen burner.

2. A blue flame should just surround the tube in centre of chimney, *and no more*, and should not burn above the top of chimney.

3. The engine must not be started until the tube has arrived at a bright red heat.

4. Move the handle on cams at side of engine *as far as it will go to the left* to release compression, and to put the ignition bowl on late safety cam. This is necessary for safety, as well as to make starting easy. After starting, reverse this handle when the engine has got up speed. *Don't leave it half-way.* In the smaller engines no handle is required, but the bowl of exhaust cam is to be moved opposite a small secondary cam, and held in position there by a pin until the engine has started.

It is *dangerous* to put one's foot on the flywheel arms in starting the engine, as with "tube ignition" the engine, *if out of order*, may turn in the wrong direction at the first explosion. Lay hold of wheel on *outside, not inside* next crank of engine.

Lubricating.—Regulate the supply of oil to the crank-shaft and connecting-rod by means of the worsted trimmers. Take the trimmers out when the engine has stopped, to prevent waste of oil, also renew the trimmers occasionally.

Oil.—It is always advisable to use oil supplied by the makers; buying oil indiscriminately nearly always leads to clogging, premature explosions, and consequent loss of power, and the mistake is not found out till the mischief is done. It should be borne in mind that the oil used in a gas engine has to stand flame temperature, and that, therefore, oils of low flash-point are not suitable, however good they may be for ordinary purposes.

The Ignition-valve.—The ignition-valve is a small brass valve, placed in some cases below the chimney, but usually alongside it. When taken out, it will be found to have a projecting end $\frac{5}{16}$in. diameter. This closes the hole leading to the cylinder during compression of charge. If it becomes too slack in this hole—permitting too great escape—it should be replaced. Interchangeable duplicates are kept by the makers. *The proper stroke or lift of this valve is $\frac{5}{16}$in.* When putting in a new one see that it has this stroke.

When wear of the cam and roller reduces this stroke to $\frac{1}{4}$in., the worn part should be changed at once, and the original stroke regained; this is *necessary for safety*, as, if neglected, the engine may reverse at starting, turning back sharply, and so endanger the attendant.

A slight escape is intended to take place through the vent-hole, in the casing, near the flange of this valve—this is necessary for safety. The hole is to be kept clean to allow of this escape; if the escape becomes too great through wear it is not to be stopped by filling up the vent-hole, which would be dangerous, but by renewing the valve if the head is worn, or, if not, by grinding in the mitre valve part.

Cleaning Ignition-valve.—The ignition-valve should be taken off weekly and cleansed with an oiled rag—*not with emery*; oil it at both ends when working.

When replacing the *ignition-valve gland in ignition block* be careful to tighten up both nuts equally, so that the valve spindle may slide up and down quite freely.

Ignition-tube.—A new ignition-tube should be put in after every 30 to 60 hours' work, as after that time they are liable to break if of wrought iron. The makers, however, supply tubes of special metal that may last 12 months.

A spare tube-holder is sent with every engine, which should always be kept at hand with a new tube in it ready for insertion in the chimney. The tubes must be firmly screwed into the holder, so as not to leak at the joint; proper tools for removing old tubes and inserting new ones are sent with each engine.

Chimney.—The perforations in the top of chimney must be kept clear. If looking down the chimney while the engine is working, shut off the cylinder gas supply, lest an accidental escape should blow dust into the eyes.

Cleaning the Cylinder.—The piston should not be taken out unless cleaning or a new ring is needed. When it is taken out, scrape out all dirt that may be found at the back of cylinder, and thoroughly clean and oil the cylinder before replacing the piston.

The big end of the connecting-rod has only to be uncoupled to enable the piston to be drawn out. The joints of all the rings should be at the *bottom of the piston.* When replacing the piston be careful that the steady-pins in the grooves fit into the gaps in the rings, or the rings may be broken when pushing in the piston.

When wear of the piston-rings occurs, *change the inside ring only at first.* Do not use force in replacing the piston.

Valves.—The exhaust, admission, and gas valves should be examined occasionally, and, if necessary, ground into their seatings with emery powder and oil. As mentioned in the instructions for the slide-valve type engines, too much attention cannot be paid to the condition of the *exhaust-valve*, and the remarks thereon apply equally to the slideless type of engine.

Water-tanks and Cooling.—Never work the engine without water in the jacket of the cylinder. The water-tanks must be kept full by a ball-cock. If the cylinder of the engine becomes much hotter than the water in the tank, the circulation is obstructed, and should be attended to.

The water-pipe from top of cylinder to top of tank must slope upwards at every point. The pipe from the bottom of cylinder to the bottom of the tank must have no bends where air can lodge.

Frost.—If the engine is exposed to frost whilst not working, burn a gas light under the cylinder *to keep the water in the cylinder-jacket from freezing*, or the water may be drawn off. *Neglect of this precaution may cause breakage of the cylinder-jacket.*

Dust and Dirt.—Protect the engine as far as possible from dust and dirt, and take care that it does not draw its air supply from a heated or impure source.

Gearing up Side Shaft.—Although in erecting these engines special instructions are given to gear up the wheels to the marks on the teeth, "O O," it is advisable to call attention to this point, as mistakes are often made in putting these wheels together.

AN INTRODUCTION TO QUALITATIVE CHEMICAL ANALYSIS.

BY BARKER NORTH, ASSOC.R.C.SC. (LOND.),

Joint Author of "Introductory Lessons" and "Hand-book of Quantitative Analysis."

[When Prof. H. E. Armstrong spoke at the Society of Arts on Mr. Robertson's paper on "Secondary Batteries," he deplored the lack of chemical knowledge among those who had the care of such batteries. The columns of a technical paper cannot contain all the information required on these subjects, but we herewith commence a short series of articles by Mr. Barker North, intended to serve as a general introduction to the study of qualitative analysis.—ED. *E. E.*]

In the following articles it will be assumed that the student has already obtained a knowledge of elementary chemistry, and as the latter is, as a rule, now taught in a more practical manner than heretofore, it will be taken for granted that the pupil has already obtained experience in the experimental portion of chemistry, such as the prepara-

tion of gases and demonstration of their properties. It is too often the case, however, that when a student has acquired skill in this branch of the subject, that he is told to at once commence the reactions of the various metals without any previous knowledge of the tests he is applying, and he thus works for a considerable time in the dark, as it were, whereas if special attention had been paid to teaching him systematically how to apply the various tests by well-chosen examples, much of his valuable time would have been saved, besides which he would have obtained a much better grasp of the subject.

It is therefore proposed to make the following a comprehensive survey of the operations which the student will have to perform in the various processes of analysis, and by working through the examples given, and making notes as he proceeds, he will acquire that manipulative skill in the carrying out of reactions which is essential for successful after-work.

Qualitative Analysis is that branch of chemical science by means of which we ascertain the nature of bodies—that is, the constituent or constituents of which they are composed. This is done by applying reagents or chemicals of known composition under certain conditions to the substance under examination; and by observing the changes which take place, such as the formation of an insoluble substance, change of colour, etc., the absence or presence of any particular element or compound may be inferred.

There are two methods of analysing in qualitative analytical chemistry—viz., by dry and wet reactions. The latter is the more reliable, and for this reason the former is too often neglected; yet the dry method will often give us the "cue" to the composition, and in some cases will even tell us the whole of the constituents present in a substance.

The dry method will be treated of first, as it should always precede the wet, in order that the latter method may be adapted, if possible, to the information thus acquired.

Chemical Manipulation—Dry Reactions.

In the Closed Tube.

This should always be the first of the dry reactions, and consists in heating a little of the dry powdered substance in a small bulb tube.

How to Make a Bulb Tube.

A piece of soft glass tubing, about 5in. or 6in. long and ¼in. in diameter, should be chosen, and held in the Bunsen flame till the middle of the tube is quite soft, when the two ends are drawn apart, thus obtaining a shape such as shown at *a*, Fig. 1. The tube is cut into two pieces at the drawn-out portion, and each is made into a bulb tube by heating the end uniformly so as to obtain the shape shown at *b*, and then by blowing gently into the open end while the other is still hot we obtain the bulb tube, *c*.

Reactions Observed: Change of Colour, Sublimation, etc.

Many changes may be observed by heating substances in the bulb tube, such as change of colour without decomposition (as in ZnO, Fe_2O_3, PbO, etc.), sublimation (Am, As, Hg, Sb, etc.), and evolution of gas (HgO, carbonates, nitrates, etc.).

After the reaction by heating the substance alone in the closed tube has been observed, a little of the substance should be mixed with dry carbonate of soda and again heated, when, if mercury or arsenic is present, a black shining mirror will be obtained in the cool part of the tube.

Experiment 1.—Heat a little of the red oxide of mercury in a bulb tube, as shown in Fig. 2. Notice, first, the change of colour; second, the black shining mirror of metallic mercury, which by rubbing with a match may be run into a globule of metal; and third, the evolution of oxygen gas, which may be proved by a glowing splinter bursting into flame on being introduced into the mouth of the tube.

Experiment 2.—Introduce a little oxide of arsenic into a small bulb tube and apply a gentle heat. Notice the sublimate of white octahedral crystals formed in the cool part of the tube.

In the Open Tube.

This is simply a straight piece of tubing about 5in. long, and about ¼in. in diameter. The powdered substance is placed about ¾in. from one end of the tube, which is inclined during heating so as to admit of the free passage of air up the tube.

Reactions Observed: Evolution of Gas, etc.

The principal reaction to be noticed in the open tube is the evolution of sulphur dioxide given off by the oxidation of the different sulphides. We also obtain sublimates in the open tube similar to those obtained in the closed, but where a difference is observed it is due to oxidation during sublimation.

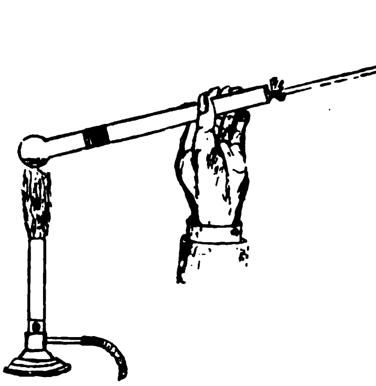

Fig. 2.

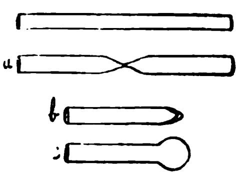

Fig. 1.

Experiment 3.—Heat a little sulphide of antimony in the open tube, and notice, first, the smell of the sulphur dioxide, and, second, that the sublimate, which consists of antimonious and antimonic oxides, is a white one, near to the substance.

Charcoal Test.

This is a very important test, and consists in heating a small portion of the substance on charcoal in the blow-pipe flame. The charcoal should not crackle on heating, and must be free from cracks, otherwise the melted beads of metal would disappear down the cavities.

The Blow-pipe and Blow-pipe Jet.

An ordinary common blow-pipe, *a*, is shown in Fig. 3, and

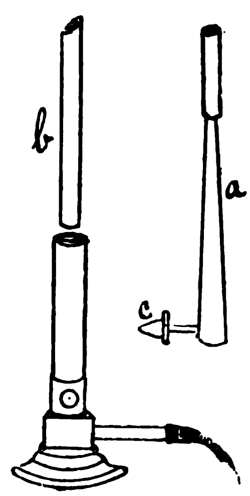

Fig. 3.

will serve all the purposes of the student, though other more elaborate looking pieces of apparatus, with platinum nozzles, may be obtained. The hole in the nozzle, *c*, should be perfectly round, and about the diameter of a pin, so as to get the best effect on blowing. The blow-pipe jet, *b*, with an inclined flattened orifice, *d*, is inserted in the barrel of a Bunsen burner, and the holes for the admission of air into the latter are meanwhile closed to prevent the gas taking fire at the bottom. The stream of air is directed down the incline, *d*, and a constant blast is maintained by keeping the cheeks inflated, and using them as a reservoir for the gradual passage of the air from the lungs to the blow-pipe, while respiration is continued through the nose.

Blow-pipe Flame: Oxidation and Reduction.

There are two parts to the blow-pipe flame, known as the reducing and oxidising flames. The former is shown at *b*,

Fig. 4, and is best obtained by just resting the tip of the blow-pipe nozzle, *c*, on the incline, *d*, of the jet, and blowing gently along the slope, while the oxidising flame, *a*, which is really beyond the visible portion, is most successfully produced by allowing the nozzle, *c*, to rest half-way down the incline, *d*, as shown, using a good strong blast. The luminous jet should be adjusted to a height of about 1½in. before commencing to blow.

Results Observed: Incrustations, Metallic Beads, etc.

A. *In Oxidising Flame.*—A small hollow for receiving a small portion of the powdered substance is made in a piece of well-scraped charcoal free from cavities, and the oxidising flame is directed on to the powder gently so as not to blow the latter away. If deflagration occurs, it indicates that nitrates or chlorates are present, but if we obtain an incrustation on the charcoal round the hole we may infer arsenic, antimony, etc. If a white incrustation is formed, or if the substance remains white, we may add a drop or two of cobalt nitrate and heat again, a change in colour of the incrustation, or substance, indicating zinc (green), magnesium (pink), tin (blue-green), or alumina (blue). The alkaline earths when heated alone in the oxidising flame are highly luminous.

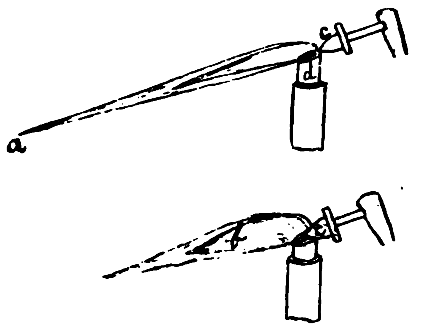

FIG. 4.

B. *In the Reducing Flame.*—The principal results to be looked for in heating a substance in the reducing flame are the beads of metal indicating lead, silver, bismuth, etc., and the changes in magnetic properties of the fused mass showing the presence of iron, nickel, or cobalt. In some cases the reduction will not take place with charcoal alone, and the powdered substance is therefore reheated after mixing with carbonate of soda or fusion mixture.

The latter is prepared by mixing sodium carbonate and potassic carbonate in the proportion of their molecular weights, about 10 parts of the former to 13 of the latter. This mixture fuses at a much lower temperature than either separately, forming the compound $KNaCO_3$.

When tin is being looked for, it will be found impossible to obtain a large bead of tin as the latter is so difficult to reduce, and in this case the substance should be heated with a mixture of sodium carbonate and potassium cyanide, afterwards crushing the fused mass in a mortar with water, and pouring off the soluble and floating matter, when the shining specks of metal may be seen with a lens at the bottom of the mortar.

Experiments 4 *and* 5.—Heat small portions of an arsenic and antimony salt in the oxidising flame, and notice that both give white incrustations, the latter being much nearer to the substance than the former, which also gives a strong garlic odour. Care should be taken not to use too much arsenic, as the poisonous effects are well known, and even small quantities are liable to produce headache.

Experiment 6.—Mix a small portion of a bismuth salt with sulphur and potassium iodide and heat gently in the oxidising flame, when a beautiful red incrustation characteristic of bismuth will make its appearance on the charcoal.

Experiment 7.—Heat a little of a zinc salt in the oxidising flame on charcoal, and to the white incrustation and substance add one or two drops of cobalt nitrate solution, afterwards reheating very strongly when a fine green mass will be obtained which indicates the presence of zinc.

Experiment 8.—Heat sulphide of lead or galena strongly on charcoal in the reducing flame till all the small beads of metal have run together into one large globule, and it will be found that the bead so obtained is malleable and marks paper.

Experiment 9.—With a salt of copper, such as nitrate of copper, mix about an equal bulk of carbonate of soda, and heat strongly on charcoal in the reducing flame for several minutes. If the experiment has been carried out successfully, a red mass of metallic copper will be obtained.

Experiment 10.—Heat a salt of iron similarly with carbonate of soda on charcoal in the reducing flame, and prove that the black residue thus remaining can be attracted by a magnet.

BORAX BEAD REACTIONS.

This will be found of great use in recognising some metals, as a few give very distinctive reactions when heated in the borax bead in the oxidising and reducing flames respectively.

Borax ($Na_2B_4O_7 10H_2O$), when heated loses its water of crystallisation and gives the anhydrous borate $Na_2O\begin{matrix}B_2O_3\\B_2O_3\end{matrix}$ and this, if brought in contact with an oxide, such as oxide of cobalt (CoO), combines with it, forming the blue double borate $Na_2OB_2O_3 + CoOB_2O_3$.

How to Make a Borax Bead.

A piece of clean platinum wire about 4in. long is taken, and a loop is made on the end not larger than this, O, by winding it round a pencil-point. The loop is then heated in the oxidising flame of the blow-pipe, and while the wire is still hot it is dipped in borax, what adheres being afterwards fused up to a clear bead. This should be shaken off whilst hot, as it will have absorbed any impurity which remained on the wire, and another bead is made in the same way by taking up borax and heating till the bead is of the proper size and quite clear.

Results Observed: Colour of Beads.

The substance to be tested is made to adhere by touching it with a hot borax bead, and by strongly heating in the oxidising and reducing flames respectively we may obtain significant colours, varying with the metals present, the colour sometimes altering during the change of the bead from hot to cold.

Experiment 11.—Make a borax bead as above described, and, after taking up a little cobalt nitrate, heat the bead strongly, first in the oxidising and then in the reducing flame. Observe the colour in each case, both hot and cold, and notice that the bead always remains of a dark blue colour, which is an unfailing test for the metal cobalt.

Experiment 12.—A good test as to whether the student can produce a good oxidising flame may be made by heating a little molybdic anhydride first in the reducing flame and afterwards in the oxidising flame. In the former case a brown bead appears, which on heating strongly in the oxidising flame, if the latter is a good one, becomes colourless.

Experiment 13.—A similar test may be made with the reducing flame by heating a little manganic oxide in it after obtaining the amethyst red bead in the oxidising flame. If a good steady reducing flame is obtained, the bead will become quite colourless.

(To be continued.)

A DESCRIPTION AND COMPARISON OF THE METHODS OF ELECTRIC LIGHTING AT PRESENT IN USE IN LONDON.*

BY ALEXANDER B. W. KENNEDY, F.R.S., M.I.C.E., ETC.

The vigorous and successful work done during the last two or three years by the various companies which are supplying electricity under Acts of Parliament has now brought the question of lighting our houses by electricity out from the region of hoping and scheming into that of practical—and already even financial—success. Nowhere has this been the case more than in London, where the whole of the metropolitan area has been parcelled out to various companies, generally two companies, having different systems

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of distribution, to each area, most of which are now in active work. Not only to electricians, therefore, but still more specially to those who are still in the outer darkness which precedes the coming of electric light, the present condition of this matter in London may be specially interesting. This is, of course, the reason for my presence here this evening. It happens that I have myself designed some of the largest distributing systems and central stations in London—stations which, I am happy to say, are already in very successful operation—and therefore I may claim, at least, the advantage of a practical knowledge of the subject on which I have to speak to you. Perhaps I may say also, although this is a purely personal matter, that it gives me special pleasure to speak on this subject in a city of which I was so long a citizen, and with which I have so many pleasant associations as Edinburgh.

I will confess, at the outset, that I always feel a lecture of this kind to be a peculiarly difficult task. Nothing is easier than to talk technically to technical men, but I have been warned by your secretary that the members of the R.S.S.A. are by no means all technical men, and that I must not at all assume even an elementary acquaintance with electrical science on the part of all my hearers. At the same time, I cannot be far wrong in assuming that some of my audience have an intimate acquaintance with the theoretical part of the matter at least, if not with the special details of what may be called metropolitan electricity. Under these trying conditions I can only express a hope that those of my audience who are electricians, or engineers, or both, will bear with me while I am dealing with matters of great familiarity to them, and that those who look on the subject simply from the point of view of good citizens who would like to use electric light if they could get it, will pardon me if at times I am somewhat more technical than interesting or instructive to them.

To begin at the beginning. There are now at work in London a number of electrical companies, each in its own district, under its own special Act of Parliament, and each performing its duties in its own way, subject to the general control of the Board of Trade and the local authorities. The function of each of these supply companies is that simply of supplying electric current as the gas companies supply gas. They build central stations in which electric energy is generated, and lay mains along the streets, past the fronts of the houses, by which this energy is distributed to consumers. The mains are, of course, of copper, either in the form of insulated cable or of naked strip carried on insulators in conduits of some kind. Any person who wishes to use the electric light has his house wired for the purpose by one of the many contractors who undertake such work, and then has this internal wiring connected up to the company's mains, just as the internal gas-pipes of a house are connected with the street gas mains. The current used in the house is measured and paid for by meter, just as gas is, and the accuracy of the electricity meter—if not yet all that it ought to be—is at least probably greater than that of the ordinary domestic gas meter.

There are certain points about the generation of electricity in central stations which are common to all the systems in use in London and elsewhere, and which it may therefore be convenient to mention first. They lie at the root of the whole matter, and some understanding of them is at first essential for following the more detailed matters of which I have to speak later on. After what I have just said, I will not therefore further apologise for dealing with points at the outset which must be "household words" to some of my audience.

First let me remind you that the whole of the electric energy generated is obtained primarily by the combustion of coal. The electric energy is just as much a transformed form of heat energy as the mechanical energy used in workshops. Therefore, electric lighting, although it will avoid the blackening of walls and ceilings, is not to be regarded as a smoke preventer, as I have sometimes found to be popularly the case. In every central station for the generation of electric energy, coal is burnt in the usual way under boilers. In these boilers steam is generated, and is in its turn employed to drive steam engines, also in the usual way. The heat energy is thus, in the first instance, transformed into mechanical energy, electricity comes in in the next process only. The steam engine is used to drive a dynamo-electric machine, usually called shortly a "dynamo," and in this way a part of its mechanical energy is finally transformed into electrical energy. The dynamo may be looked at as the pump which pumps the electric current along the solid copper of the mains,* just as the pumping engine at water works pumps the water through the pipes

It is well that you should have some clear notion of what this most important piece of apparatus—the dynamo—is, and does. By far the best elementary illustration of the working of a dynamo machine which I have seen is one given last year in a lecture by Mr. Preece, and as you may not know it, I shall not hesitate to pass it on to you. It is a well-known fact in electricity that if a wire of conducting material, such as copper, be moved across the space between the poles of a magnet, what we call a current of electricity traverses that wire for the instant. A dynamo in its simplest form is a machine consisting of a very powerful electromagnet or magnets, between the poles of which a large cylinder of wires or bars, called an armature, is caused to revolve rapidly by a steam engine. Twice or oftener in every revolution, therefore, as a consequence of this forced motion of the conducting wires across the magnetic field, a current passes through each wire, and these currents, collected and directed by special apparatus, are the currents which traverse the mains and are utilised for lighting or for power, etc. The current in the mains thus consists of an accumulation or addition of an immense number of small currents, just as a river is the addition of an immense number of raindrops. As used for lighting, this river is again subdivided, just as an actual river would be if, near its mouth, the whole of its flowing water were taken away through endless channels for the purpose of irrigating land.

Mr. Preece's illustration was this: The earth is a huge, although feeble, magnet. Suppose a man stands anywhere between the north and south magnetic poles of the earth, facing one of them, takes in each hand one end of a piece of flexible copper wire, and proceeds to use the wire as a skipping-rope. As he skips, a current will be generated in the wire, and will pass through it and round through his body from hand to hand. The current will be excessively feeble, but could be measured by sufficiently delicate apparatus. The man in this illustration takes the place of a steam engine—he simply employs mechanical energy derived from the internal combustion of certain organic materials to swing his arms and drive the wire, which forms his armature. The magnet of this dynamo is, of course, the earth. The illustration is really both exact and striking. Substitute a powerful steam engine for the skipping citizen, a strong electromagnet for the earth, replace the single wire with a cylinder or a set of bobbins containing a very large number of wires, and increase the speed of skipping to 400, 600, or perhaps 1,000 revolutions a minute, and you have the ordinary dynamo of commerce, the sort of machine which is used—in endless modifications of course—in all central stations.

It is important that you should not think of the central stations generating electricity in the sense of creating it. The machinery only makes existing electricity available for doing work—it creates nothing. Into the most difficult question of the real nature of electricity, and its relation to the ether which fills space—if, indeed, itself be not this ether—it is obviously undesirable that I should enter to-night, even if the subject were one which I was competent to discuss. Without any pretence, therefore, to its being more than an approximate analogy, it may help you in following my further remarks if you think of things something in this way: Imagine a great pumping station for the supply of water under pressure to houses, for any purposes. Let there be beside it a very large reservoir of water. Let there be a double set of mains laid along the street, one main carrying the water to the houses, the other being, in fact, a drain to receive all the waste water from the houses, but carrying it back to the reservoir, and not to waste, if one may be allowed to suggest such a thing. If we further suppose the reservoir to be at a

* I hope I may be pardoned for ignoring for an hour the more modern view of the matter.

somewhat lower level than the houses, it is obvious that it might be standing full of water, containing any number of million gallons stored up, and yet the householder would be unable by any possibility to get a drop through the pipes into his house. (This, by the way, represents the present condition of Edinburgh in respect to electricity, except that the pipes are not yet laid!)

Now, in the station beside the reservoir let us suppose a pumping engine to be placed, and connected with the mains. Let it be arranged so as to draw water from the reservoir and force it under pressure through the pipes. No water is created, nothing exists which did not exist before, but now each householder can get whatever water he wants, whether to fill a bath or to work a lift, by simply turning on a tap. The engine simply does the work of pumping into his house. The reservoir never gets empty—indeed, the quantity of water in it never changes, for I have supposed that all the water used finds its way back through the return main.

In like manner the whole space around us is a vast inexhaustible reservoir of electricity. The dynamo is merely a pump which forces it under pressure through certain definite channels. These channels are made double ("go" and "return), in order to ensure greater certainty of working, but theoretically we might run a single main only, and allow the current to return by earth, just as we might allow the waste water to soak into the earth and so find its way eventually back to its reservoir. There are practical drawbacks about an earth return in both cases!

Just as we measure the flow of water in pounds per hour and its pressure in feet of head, so we measure the current (or rate of flow) and its pressure, in suitable units, which we call amperes and volts respectively, the former being analogous to the flow of water, the latter to its head or pressure.

It must be borne in mind that whatever electrical pressure it may be most convenient to use in the mains, the actual pressure at the customers' lamps must be constant, and nearly everywhere is fixed at about 100 volts. A variation of as much as 4 per cent. upwards from this will increase the brilliancy of the lamps very much, but decrease their life, while a variation of 4 per cent. downwards would very seriously indeed diminish the light. As a matter of fact, therefore, all the supply companies do their best to keep the pressure at their customers' lamps as nearly as possible constant at 100 volts.

The companies supplying electrical energy in London may be roughly classified in two different ways—namely, (1) as using high or low pressure in their mains, and (2) as using alternating or continuous currents. With one exception the two divisions are conterminous.

The three high-tension companies at present working are the Metropolitan, the London, and the House-to-House. The first-named covers most of the residential district north of Oxford-street, and includes also Lincoln's-inn-fields and other parts of the region between Oxford-street and Fleet-street, and round Charing Cross. It has stations at Sardinia-street, Rathbone-place, and near Manchester-square, besides a low-tension station at Whitehall, and a new station in process of erection at Paddington. The London Electric Supply Corporation has one generating station only, at Deptford, about six miles from Charing Cross, but has also several distributing stations over its district, which covers an irregular and very widely-extended area, including some of the best parts of Central London. The House-to-House Company has a small residential district at West Brompton supplied from one station.

Among low-tension companies the largest is the Westminster Electric Supply Corporation, with which I am myself connected, and which has, for its area of supply, Westminster (including the Houses of Parliament), Pimlico, Belgravia (with Buckingham Palace), and Mayfair, marching with the Metropolitan Company along Oxford-street. It has three central stations—one in Westminster, one in Belgravia, and one in Mayfair. Its district fortunately includes offices, shops, hotels, clubs, and private residences as well. The Kensington and Knightsbridge Company have a district at South Kensington mainly residential, with two stations and a battery station. The St. James's and Pall Mall Company have the cream of the lighting in London—that region in St. James's which is familiarly known as "Club Land"—which they light from one station in the centre of it. They are about to build another station for the northern part of their district. The Electricity Supply Company (Strand district) has a station near Covent Garden. The Notting Hill Company has a district mainly residential; its station has been very recently opened. In St. Pancras the matter has been taken up by the Vestry itself, and its first station will soon be ready.

All the high-tension companies mentioned use alternating currents, and all the low-tension companies use continuous or direct currents. The Chelsea Company, however, which has a station near Sloane-square, distributes continuous currents at high pressure on a system which I shall describe later on.

It is, of course, impossible here to make any exhaustive comparison of the merits of the different systems adopted in London. I will say at once, also, that I am not one of those who think that any one system has all the merits to itself. Indeed, I think it is quite open to doubt whether, for instance, the system which is best adapted for St. James's is also best adapted for Brompton. It is certainly not necessarily so, and I know personally that the different systems employed have been adopted in each case after careful consideration of their special circumstances by those responsible for the scheme. Whether or not a particular system is best in a particular place is not a matter which can be decided off-hand by mere expression of opinion, and without regard to the special conditions involved. I shall endeavour to give you, as fairly as I can, a sketch of the *pros* and *cons.* of the principal points of difference between the systems adopted.

First, as to the main division which I have mentioned between the systems, that, namely, between distribution at high and low pressure, or tension, as it is more often called. The analogy of water may here again be made use of. If it be required to do a given amount of work by water power, it can be done either by the use of a large quantity of water at a small head, or of a small quantity with a very high head or pressure. As we may otherwise express it, a given amount of energy may be furnished by the aid of water, either by sending a large quantity of water through the mains at a low pressure, or a small quantity at a high pressure. The work done, or the effect in energy, depends on the product of quantity and pressure—*e.g.*, 100lb. of water per minute at a head of 10ft. is equivalent to 1lb. per minute under a head of 1,000ft., although it is to be noted that a much smaller pipe would be necessary to convey the 1lb. than the 100lb. Exactly the same is true of electricity. One hundred amperes at a presure of 100 volts is the exact equivalent of 10 amperes at a pressure of 1,000 volts. The importance of this point is easily seen. When a current of electricity passes along the copper conductor or wire, which takes the place in this case of the hollow water main, a certain resistance is experienced analogous to the frictional resistance which accompanies the motion of water through a pipe. With a copper main of a given cross-sectional area this resistance increases—within certain limits—in direct proportion to the magnitude of the current—that is, double the current gives double the resistance, etc. Moreover, this resistance, like friction, is accompanied by the generation of heat; the copper conveying the current becomes hot, and a certain point is easily reached at which the heat so generated is sufficient to injure the insulating material round the metal. Whether or not, however, the heat should be unduly great, all the work done against the resistance is absolutely wasted, for useful purposes, exactly as is the similar work done in pumping water. Practically it is found by most low-tension companies that it is on these grounds inadvisable to allow copper mains to carry a current of more than 600 or 700 amperes per square inch of cross-section. As the output of a large station at full load is measured in thousands of amperes, this means that the trunk mains must have, in all, an area of several square inches, which is, of course, a very expensive matter.

On the other hand, the amount of current which a copper rod will carry is not affected by the pressure at which the

current is circulating. Hence there is an obvious *primâ facie* advantage in the use of a high pressure. It allows the quantity of current for any given amount of electrical energy to be reduced just in proportion as the pressure is increased, and as the former only affects the size of the mains, the use of high tension—other things being equal—allows the weight of copper in the mains to be reduced very materially. Moreover, by using a pressure so high that the loss of head in forcing the current through the mains is negligible, or at least is proportionately very small, the generating station can be placed at a considerable distance, several miles for example, from the district supplied. In itself this is, of course, not desirable—indeed, it is most undesirable—but naturally there may be places where the erection of a lighting station in the centre of a district which it has to supply is for certain sufficient reasons impossible.

I have said that the pressure of electricity in the customers' houses is a low pressure, and must be everywhere the same, whatever may be the pressure in the mains. Practically it is always about 100 volts. Hence clearly a distribution at high pressure would be impossible if there did not exist some ready means of changing the pressure from high to low at the customer's house. This requirement is met by the transformer or converter, which is at once the blessing and the trouble of the high-tension systems. To explain to you the nature of this apparatus, I am sorry to say that I have to leave my hydraulic analogy, which appears to furnish no parallel case. and must take the thing just as it stands.

It is necessary before doing this to look for a moment at the other division between the London companies—namely, the use of continuous and alternating currents—pointing out at the outset that so far as house-lighting goes, there is no difference between them, but that as yet motors have practically only been driven by continuous currents. If you recollect my description of the way in which current is produced by a dynamo, you will see that that current really cannot be completely continuous. It consists of a series of very rapidly-occurring successive flows of current. For all practical purposes, however, this current may be treated as continuous, for by a piece of apparatus called a commutator, which forms part of the dynamo, all the currents are made to flow in the same direction. A really continuous current is only furnished by a battery, but so far as all its leading characteristics and its measurement go, the current from a continuous-current dynamo is identical with that furnished by a battery.

Such a current, as we shall see directly, cannot be transformed in pressure in the way I have alluded to. It is quite possible, however, to arrange a dynamo—which then requires no commutator—so that it delivers its current, not continuously, but in what may be called wavelets, swinging first forward, then back. An electric current of this kind is called an alternating current, and is used by all the high-tension companies which I have mentioned in London. Each wave of current is complete in itself, and occupies generally from one-eightieth to one-hundredth of a second, forming a complete cycle of what—in default of a better expression—we may call a go and return current, and between each pair of waves the current is zero—that is, the flow ceases absolutely, although for an infinitesimally short time.

(To be continued.)

MODERN APPLICATIONS OF ELECTRICITY TO METALLURGY.*

BY G. C. V. HOLMES, SEC.I.N.A.

(Concluded from page 137).

Applications of the Elmore Process to Manufactures.—It might probably at first be thought that in consequence of the copper being deposited on a mandrel in the form of a tube this process was very limited in its application, and that few kinds of articles could be manufactured by it. This is, however, not the case. Such goods as steam-pipes, calico printers' and other rollers, the coatings of hydraulic ram-plungers and, in fact, anything of a plain circular section can, of course, easily be made, but so also can sheet copper, tape for electric lighting, pots and pans of circular section and with flat or curved bottoms, cartridge cases for heavy and quick-firing guns; also high-conductivity wire can be produced by simply cutting and drawing without melting the deposited metal.

If a tube be cut open in the direction of its length and flattened out, a single sheet is produced, the size of the sheet being dependent solely on the diameter and length of the mandrel. It would, however, be a tedious operation to remove a large mandrel from the tanks and remove the tube from it every time it was required to make a sheet. The Messrs. Elmore have got over this difficulty in the most ingenious way by taking advantage of the severance of continuity in the metal that results from oxidising the surface, either by interrupting or reversing the current. In this way they can form a tube, the walls of which, to all appearance, are perfectly solid, but which in reality are laminated throughout. The thickness of the separate layers or laminations can be regulated to a nicety, and when the built-up tube is withdrawn from its mandrel and cut open it separates up into its constituent layers, so that instead of one sheet several can be obtained.

Tape for electric lighting can be produced by cutting up a simple or a laminated tube spirally in a lathe or in a special cutting machine and unwinding the spiral. You can thus produce, without rolling or heating, a strip of rectangular section and of perfectly pure copper. This is a product which will be highly valued by electric lighting engineers, for even a minute percentage of copper oxide in the metal considerably reduces the conductivity of the material.

Wire for electric purposes is made by depositing a tube as usual and cutting it into a spiral as before, but of square section. The strip thus formed is drawn through dies in the usual manner. This process for making wire compares most favourably with the older method, to which reference was made in the earlier portion of the paper. The copper being absolutely pure is of very high conductivity, and always perfectly uniform. It possesses also the advantage that it can be drawn through a great number of holes without being re-annealed.

Results of Experiments with Copper produced by the Elmore Process.—Messrs. Clark Forde and Taylor have carried out experiments on the qualities of wire made under this process, which have given most interesting and important results. The conductivity of the hardest Elmore wire having a breaking strain of 29 tons per square inch was found to be about 2½ per cent. higher than that of soft annealed wire of the best quality hitherto procured commercially, and the annealed Elmore wire has a conducting power 4½ per cent. above that of the best commercial copper. The hardness of the wire tested was so great that the elongation under the strain at the rate of 29 tons per square inch was only ¾ per cent.

The tensile strength, elastic limit, and extensions under strain of Elmore tubes may best be illustrated by reference to the accompanying table of results obtained by Prof. W. C. Unwin, F.R.S., and Prof. A. B. W. Kennedy, F.R.S. They show many interesting features. The tensile strength is proved to be equal to that of mild steel instead of that hitherto accepted for commercial sheet copper, which latter is usually about 14 tons per square inch. In one instance the tensile strength of the Elmore sheet reached the extraordinary limit of 42·28 tons per square inch. The widely diverging results are not due to accident, but can be reproduced at will to suit varying requirements by altering the conditions of deposition. Another most important point brought out by the experiments is the very high ratio of elastic limit to breaking load. This ratio is perfectly under the control of the manufacturer. In some instances it came out as high as 0·92, which means that the material might be loaded up to 92 per cent. of its ultimate breaking strain and yet return to its original dimensions. This quality in engineering structures is of course of great importance. Equally satisfactory are the figures showing the percentages of extension and reduction of area of fracture. These prove the extreme ductility and uniformity of the material even when worked cold.

The test marked "annealed," third from the bottom of the list, is worthy of particular attention. The process of heating and annealing had reduced the tensile strength of the material to 14·78 tons per square inch, which is about the strength of good commercial sheet unannealed, but the extension on the length of 3in. was no less than 62·3 per cent. This reduction of strength, due to heating, is inherent in all coppers, no matter what the process of manufacture may be, but it is worthy of remark that it is quite unnecessary to heat the copper deposited under the burnisher for the purpose of working it, for even such difficult operations as flanging a pipe can be carried out with ease successfully in the cold state. The numerous samples exhibited, all of which have been worked cold, prove this; but perhaps a still more convincing proof is furnished by the record of an extraordinary experiment carried out by the well-known French firm of coppersmiths, Messrs. Guéldry,

* Paper read before the Junior Engineering Society, Jan. 15.

TABLE II.—Table showing the Results of Tensile Tests, carried out some by Prof. W. C. Unwin, F.R.S., and some by Prof. A. B. W. Kennedy, F.R.S., made on Pieces of Copper cut from Tubes deposited by the Elmore Process.

Breadth of sample, inches.	Thickness, inches.	Area, square inches.	Limit of elasticity Tons per square inch.	Breaking load. Tons per square inch.	Ratio of limit of elasticity to breaking load.	Length on which extension was measured, inches.	Extension per cent.	Reduction of area at fracture, per cent.
1·252	0·148	0·185	23·61	25 54	0·924	4	21·2	66·0
1·255	0·148	0·186	21·60	25·71	0·840	4	20·7	67·5
1·255	0·147	0·184	21·30	24·88	0·850	4	21·0	61·6
1·880	0·142	0·267	—	24·60	—	{ 10 8	12·3 14·1	— —
1·880	0·142	0·267	—	24·50	—	{ 10 8	11·8 13·9	— —
1·880	0·142	0·267	—	24·07	—	{ 10 8	11·2 12·9	— —
1·245	0·135	0·168	22·05	26·64	0·828	4	17·5	70·5
1·263	0·131	0·165	24·83	26 83	0·925	4	14·3	63·5
1·272	0·131	0·167	23·03	25·92	0 888	4	17·5	66·0
1·226	0·049	0·060074	—	39 29	—	10	5·1	—
1·221	0·050	0·06105	—	42·28	—	10	7·0	—
1·487	0·050	0·074	18·03	27·52	0 65	10	6·2	—
1·504	0 050	0·075	16 62	26·77	0·62	10	7·7	—
1·508	0·084	0·127	14·80	29·46	0·50	10	3·8	—
1·490	0·084	0·125	15·00	30·17	0·50	10	3·5	—
1·981	0·081	0 160	13·9	28 93	0·48	10	3·4	—
1·981	0 079	0·156	17·1	28·82	0·59	10	3·3	—
1·380	0 060	0 083	—	25·94	—	3	20·0	—
1·380	0·060	0·083	—	26·64	—	3	19·0	—
1·385	0·060	0·083	—	14·78	Annealed	3	62·3	—
2·007	0·050	0 100	—	27·82	—	3	4·0	—
2·000	0·052	0·104	—	27·18	—	3	6·7	—

Grimault, et Tillier, of 66, rue Amelot, Paris. They reported, 9th December, 1891:

"We have tried and tested in every way the last copper tubes of 52·48 millimetres, which you sent to us on the 3rd inst. Without annealing we have been able, by drawing out the tube on a mandrel, to reduce the thickness from two millimetres to $\frac{6}{10}$ths of a millimetre, and the outside diameter from 52 millimetres to six millimetres, and we could have drawn it still further down. Without annealing we have been able, by drawing out the tube without a mandrel, to reduce the diameter from 52 millimetres down to 14 millimetres, bringing the thickness from two millimetres up to three millimetres. All these manipulations have not in the least injured the metal, which remained equally malleable and rigid—a result simply marvellous. Our conclusion is that you can now produce perfect tubes, and of a quality hitherto unknown."

The writer has dwelt at great length on the physical qualities of copper deposited under the system of continuous burnishing, because it is by these qualities that the material must stand or fall.

Cost of Manufacture by the Elmore Process.—The remarks which have been previously made on the cost of electro-refining copper apply equally to the Elmore process. The mere cost of deposition must be the same in both cases, such elements as cost of labour, fuel, etc., being the same—provided that the difference of potential between the terminals of each tank and the quantity of the current remain the same.

Owing to the arrangements of anode and cathode not being so favourable as in the refining process the resistance of the tanks must be somewhat more, and this cause, coupled with the greater current density used in the burnishing process, makes it necessary to work with a higher difference of potential per tank. The actual difference varies according to the size and number of mandrels in each tank and the arrangement of the anodes. In practice, it may on the average be taken as two-thirds of a volt, at which figure, as already seen, a ton of copper can be deposited for each ton of coal burnt in the furnaces of the boilers which supply the dynamo engines. The extra cost of plant required for the burnishing process must be taken into account, though this is partly neutralised by the increased current density which can be used. The cost of cyaniding, of adjusting the mandrels in the bath and removing the tubes from the latter, must all be considered; but the author is informed that, when every item of increased expenditure has been taken into account, the whole cost of manufacture on an output of from 20 to 30 tons per week comes to about ½d. per pound weight of manufactured article. This result is certainly satisfactory.

The subject for this paper has been chosen by the author partly because it is one of comparative novelty, and partly because he believes that electro-metallurgy is destined to be an important factor in our national industry, and that it will consequently afford a profitable field of employment for the engineers of the rising generation. We are now only on the fringe of the subject. Copper has yielded first to the efforts of the electrician because it happens to stand at the very bottom of the list of commercial metals given in Table I. (*vide E.E.* Jan. 22), but the others will follow sooner or later, though their treatment will not be quite so easy. Already results have been heard of and even specimens seen which are of the brightest augury for the future, and for this reason the author has not hesitated to present an elementary and necessarily imperfect account of recent improvements in the electro-metallurgy of copper.

GLASGOW TRAMWAYS.

COMPARATIVE STATEMENTS OF COST OF TRACTION BY VARIOUS SYSTEMS OF HAULAGE.

First.—ANIMAL TRACTION.—For the year ending 1890 traction on the Glasgow tramways, including maintenance and renewal of the plant therewith connected, in so far as that can be ascertained from the published accounts, cost 6·031 pence per car mile.

Second.—ELECTRIC TRACTION BY ACCUMULATORS.—The cost of working, based on offers received, and adding thereto the further charges necessary to cover outlays corresponding to these embraced in the cost of animal traction, and also interest at 5 per cent. on the excess of capital required for working by accumulators as compared with animal haulage, amounts to 4·951 pence per car mile.

Third.—CABLE POWER TRACTION.—The cost of working, based on offers received, and adding thereto the further charges and interest as before stated, amounts to 5·053 pence per car mile.

It would thus appear that mechanical power by electric accumulators is fully a penny per car mile run less than animal traction, and by cable haulage, on an extended system, a saving of rather under a penny per car mile run.

Mechanical haulage should be less liable to increased cost from such incidents as are liable to affect animal haulage. For example, provender for the horses on the Glasgow tramways has cost for the half-year ending December 31, 1891, fully 21 per cent. more than in the half-year ending December 31, 1890, and it is the cost for the year 1890 on which the foregoing figures have been prepared. The increased cost per car mile for provender alone will be about one-third of a penny per car mile run.

Of course the cost for animal haulage in Glasgow is an ascertained fact. The cost of mechanical haulage, as before given, although mainly based on offers received, has nevertheless some items, such as maintenance of track, etc., which can be actually ascertained only when such systems of haulage have been in use for some time, but the margin of about a penny per car mile in favour of mechanical haulage should be an ample allowance for such contingencies.

The receipts on tramways worked by mechanical haulage are as a rule greater per car mile than on cars worked by animal power.

PORTSMOUTH.

According to our advices the question of electric lighting at Portsmouth has not been settled without some squabbling. We do not approve of the procedure, but refrain from criticism, being content to give the position of affairs as it seems to stand at the present time. At the last meeting of the Council the Electric Lighting Committee again brought up their report, recommending that the portion of the resolution previously passed by the Council adopting Mr Shoolbred's scheme for the electric lighting of the borough be rescinded; submitting Prof. Garnett's report, and recommending its adoption; and recommending, further, that the committee be authorised to acquire a sufficient site for the central station.

Alderman Ellis, in moving the adoption of the first recommendation, said Mr. Shoolbred's estimate in respect of the private lighting scheme was that each lamp would earn £1. 6s. per annum, whereas it came to the committee's knowledge that the average earnings of a lamp were only £1. They invited Mr. Shoolbred down to prove his estimate, but the only English town he cited in support of this figure of £1. 6s. was Bradford. The speaker then went to Southampton, where the nearest electric lighting station was in existence, and found that the average earnings per lamp there were only 18s. To adopt Mr. Shoolbred's scheme, under the circumstances, would probably have meant a loss of thousands of pounds of the ratepayers' money per annum. Under these circumstances the committee felt it was only the right thing to do to come before the Council, admit their mistake, and make the present recommendation that the resolution adopting Mr. Shoolbred's scheme be rescinded. Prof. Garnett's report did not come in for many days after this decision had been arrived at in committee.

Mr. Dittman seconded the resolution.

Alderman Ellis next moved the second clause, recommending that the scheme and report of Prof. Garnett should be adopted, that he be appointed as consulting engineer, and that Messrs. Waller and Manville be appointed superintendent engineers, the fees for both together being £1,500. He said they were

not proposing any new-fangled notion which had not been tried in other towns, but one which would, when the whole of their lights were going, give a profit of £3,000 per year. He further said that all the practical men to whom he had mentioned the utilisation of the tide in producing power for electricity had laughed at the idea.

Mr. H. P. Foster seconded the clause.

Sir W. Pink disclaimed having any antagonism to the scheme or to any desire for postponing the matter, but he moved as an amendment the resolution of which he had given notice, and which was as follows : "That it be an instruction to the Electric Lighting Committee to consider and obtain information as to the possibility of utilising tidal power for the lighting of those parts of the borough contemplated in the provisional order, and to report to the Council." He supported his view by reading a letter from Colonel Crease, who pointed out the value of the power of the tide at Langstone Harbour. Another letter which he read was from Sir F. Bramwell, who held a similar view, and suggested that a bridge between Hayling and Southsea might be included in the scheme. He knew that the electrical papers had "pooh-poohed" Prof. Garnett's report as to electricity for Portsmouth, but with that he had nothing then to do, though if by a few weeks' postponement they could only get a constant power with only a first expenditure it would be worth consideration.

Mr. Miller seconded the amendment, and deprecated the adding of another burden to their present debt for that which would be a luxury only.

After a long and acrimonious discussion, the amendment was lost by the casting vote of the Mayor, and the resolution carried by 21 to 17 votes.

LYNN.

A lecture on "Electric Lighting" was given the other evening before the members of the Lynn Students' Association by Mr. E. J. Silcock, C.E.

Mr. Silcock, in the course of a long and carefully-prepared lecture, dealt with the ancient mode of lighting by torches, oil lamps, and gas, which, he said, were immense strides towards a perfect system, though he hoped to convince them that electric lighting was far in advance of either, more especially from a health point of view. Although only of very recent growth, it had come to a very high state of excellence, and was now long past the experimental stage. This result was due to the fact that there were and had been many workers in the field, amongst them men with the keenest scientific intellects and the best scientific training of the day. No satisfactory answer could be given to the enquiry, "What is electricity?" though there was perhaps no phenomenon of nature which had been more closely studied, or whose effects could be more accurately measured and foretold than electricity. It could be conveyed from one point to another by means of conductors, and was produced by friction, chemical combustion, and by induction. Having explained the technical terms used in electrical matters, he went on to describe the various machines by means of diagrams, following with information as to the working of incandescent and arc lamps. Storage of electricity was also dealt with, and as to the cost he said that it was a mistaken idea to suppose it was very expensive, and therefore only the light of the rich. The cost was very little in excess of gas, and if all circumstances were taken into consideration it was much cheaper. One pound of coal placed in a retort and distilled would produce about five cubic feet of gas, which would produce with the best appliances a light of 16 candles for an hour. If the same coal was placed in a boiler and used to make steam to drive an engine and dynamo, it would, in an incandescent lamp, give three times the light, and in an arc lamp 18 times as much. Electric lights were so easily lighted that a great saving was effected by those who used it, because they only turned the light on just when they wanted it, whereas the trouble of lighting gas and putting it out prevented it being so economically used. A saving was also effected, because furniture, etc., was not deteriorated as with gas. When health was considered, electric lighting was a long way ahead of all other means of lighting. Gas, candles, petroleum, etc., contaminated the air, and loaded it with carbonic gas, sulphuric, and other injurious gases. The latter part of the lecture was illustrated by diagrams giving the oxygen consumed, carbonic acid produced, the air vitiated, and the heat produced by the combustion of certain bodies burned so as to give the light of 12 standard candles for one hour. He concluded by expressing the hope that it would not be many years before there was a public supply of electric light in Lynn, by means of which any householder who desired it might be supplied.

COMPANIES' MEETINGS.

LIVERPOOL OVERHEAD RAILWAY COMPANY.

The half-yearly meeting of this Company was held on Tuesday at Liverpool. Sir William Forwood presided.

The **Chairman**, in moving the adoption of the report, said they had spent during the past half-year in the construction of the railway £103,515, which made a total expenditure up to date of £357,361. The construction of the railway had made rapid progress; the line was completed more than half-way; the foundations were completed right over the whole length; and nearly all the columns had been fixed. The Directors had lately visited the Electric Construction Corporation's works at Wolverhampton and inspected the electric plant, and they were satisfied that when brought into play it would work effectually. They expected that the railway would be completed and open for traffic during the autumn.

Mr. Richard Hobson seconded the motion, which was carried.

A special meeting was held subsequently to consider a proposal to raise £75,000 by the issue of debenture stock to that amount.

The **Chairman** said the resolution was a formal one, and it was agreed to *nem. con.*

A further special meeting was held to decide as to the promotion of a Bill in Parliament "to extend the time for the construction of certain authorised railways, and to authorise the Liverpool Overhead Railway Company to make certain extension railways, and for other purposes."

The **Chairman** said that as they were going to Parliament for an extension of time, they thought it well to ask for powers to include two other projects, one to extend the south end of the line some 800 yards, so as to bring it into connection with the Cheshire Lines system, and another at the north end, 200 yards in length, as far as the Crosby-road and close to the Lancashire and Yorkshire line; thus placing the overhead railway in direct touch with Manchester, East Lancashire, and Yorkshire, as well as important suburban and residential districts, greatly to the convenience of manufacturers and others.

The resolution was adopted.

CUBA SUBMARINE TELEGRAPH COMPANY.

The forty-first ordinary general meeting of this Company was held on Wednesday at the Company's offices, 58, Old Broad-street, E.C., Mr. Thomas Greenwood presiding.

The **Chairman** said that the accounts very much resembled those that were presented 12 months ago, the difference on either side being very small. Their income had been £380 more than that of the corresponding period last year, while they had saved about £50 in working expenses, which gave them £370 to the good, comparing one half-year with the other. They had taken from the balance £170. These sums together enabled them to put to the reserve fund £5,000, as against £4,450 in the corresponding period of the previous year. Nothing had been spent on repairs, as there had been no interruption of their cables. The average amount spent on repairs each half-year would amount to £3,000, a sum which, though it did not figure in the present, would in some future accounts. He concluded by moving the adoption of the report and accounts.

This was seconded by **Mr. Alexander F. Low**, and carried.

Dividends at the rate of 10 per cent. per annum on the preference and 8 per cent. on the ordinary shares were afterwards declared.

COMPANIES' REPORTS.

BIRMINGHAM ELECTRIC SUPPLY COMPANY.

The following report of the Directors will be submitted to the shareholders at the forthcoming ordinary general meeting of the Company :

Your Directors have pleasure in presenting their report and balance-sheet for the past nine months. It will be in your recollection that the accounts presented at the first annual meeting were made up to March 31 last. The alteration of the date of closing the financial year has been adopted to accord with the requirements of the Board of Trade. The accounts submitted herewith show a profit of £713. 16s. 4d., and, taking into consideration the fact that these accounts include the supply during the six summer months, the result cannot but be deemed satisfactory. Of this sum the Directors have applied £351. 16s. 7d. to depreciation reserve account, and recommend that the balance be carried forward to next year's account. The capital expenditure on buildings, plant, and mains during the nine months amounts to £7,761. 16s. 7d., this sum including a battery of accumulators and a fourth engine and dynamo. The demand for the light has been most satisfactory—the total number of 16-c.p. lamps, or the equivalent, on order at the 31st December being 5,480, which has since been increased by additions to 6,100. It will be of interest to note the company have now on their books as customers two hotels, five clubs, four public buildings, two institutions, 11 restaurants, 60 shops, two banks, eight insurance offices, 56 general offices. From the very ready way in which the light has been taken up the Directors fully anticipate a large increase in the output of the station, and in contemplation of this they propose putting down further plant to meet such demand. It is also intended to extend the mains through a portion of the areas allotted to the Company last year. There still remain of the Company's capital 5,625 shares unallotted, and the Directors consider that the time has arrived when it will be an advantage to the Company that these shares should be taken up. These will at once be offered to the shareholders, and afterwards to the public, at the discretion of the Directors. Two Directors, Mr. J. F. Albright and Mr. G. H. Johnstone, retire, and, being eligible, offer themselves for re-election. The auditors, Messrs. Sharp, Parsons, and Co., retire, and, being eligible, offer themselves for re-election.

NEW COMPANIES REGISTERED.

Tavernier's French Patents, Limited.—Registered by Williams and Neville, 23, Austinfriars, E.C., with a capital of £1,200 in £1 shares. Object: to acquire from A. E. Tavernier an electrical apparatus for the automatic indication of fire and the rise of temperature in the bearings of machinery, and the patent rights belonging thereto, and to develop and turn to account the same, in accordance with an agreement, particulars of which are not given.

BUSINESS NOTES.

Great Northern Telegraph Company. — The receipts for January were £20,000.

The Northern Electric Wire Company, of Halifax, have been able to again declare their usual dividend of 7½ per cent. per annum and carry forward a credit balance to next year's working.

Dividend.—The Telegraph Construction and Maintenance Company propose a dividend of 15 per cent. (£1. 16s. per share) in addition to the 5 per cent. already paid, making 20 per cent. for the year 1891.

City and South London Railway.—The poll demanded by Mr. Middleton at the meeting of this Company last week, on the question of the approval of the Islington Extension Bill, was taken at the Company's offices on Tuesday last. The result was a large majority in favour of proceeding with the Bill. The receipts for the week ending 7th February were £824, against £702 for the corresponding period of last year, showing an increase of £122. The receipts for last week showed an increase over those for the week ending January 31st of £1.

PROVISIONAL PATENTS, 1892.

February 1.

1876. **Improvements in alternating-current electromotors.** Rankin Kennedy, Carntyne Electric Works, Shettleston, Glasgow.

1878. **Improvements in means or apparatus for protecting underground electrical conductors.** Frederick Davis and Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.

1880. **Improvements in electrical sound-producing apparatus.** Arnold Beaumont Woakes, 78, Harley-street, London.

1883. **Improvements in electrical telephone transmitters** William Lucas and Thomas Alexander Garrett, 53, Thornhill-square, Barnsbury, London.

1906. **Improvements in shades for electric lamps.** John George Byworth, 323, High Holborn, London.

1908. **An improved form of automatic accumulator, charging switch, and safety cut-out.** Thomas Barnet Grant, 15, George-street, Mansion House, London.

1924. **An electric switch.** George Sylvester Grimston, 28, Southampton-buildings, London.

1927. **An improvement in secondary voltaic batteries.** William Joseph Starkey Barber-Starkey, 28, Southampton-buildings, London.

February 2.

2008. **Improvements in electric light decorations.** Edmund Rathbone, 4, Clayton-square, Liverpool.

2012. **Improvements in synchronous electrical signalling apparatus.** George William Hart, 11, Furnival-street, Holborn, London.

2016. **An improved block for use in forming conduits for electrical or other cables or wires and for analogous purposes.** John Price, jun., 17, Southampton-buildings, London. (Complete specification.)

2017. **A new or improved method of and means for making zinc rods for electric bells and batteries.** George Turner, 46, Richmond-road, Dalston, London.

2020. **Improvements relating to electrical signalling on railways.** Charles William Catt, 6, Bream's-buildings, London.

2026. **Improvements in electric telephones.** Henry Harris Lake, 45, Southampton-buildings, London. (Elwood Aristides Grissinger and Theodore Grissinger, United States.) (Complete specification.)

2055. **Improvements in or relating to apparatus for closing electric circuits, for use in connection with position finders or the like.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Giulio Bertolini, Italy.)

February 3.

2064. **Improvements in the construction of electro-pneumatic pressellos for electric bells and signals.** Walter David Parr, 167, Grunesthorpe-road, Sheffield.

2106. **Improvements in heating and welding by electricity.** Henry Howard, 24, Southampton-buildings, London.

2109. **Improvements in arrangements and apparatus for telegraph message signalling and other purposes.** Frederick *Thomas* Hollins, 10, Forest-drive East, Leytonstone Essex

February 4.

2163 **Improvements in electric measuring apparatus.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.

2198. **Improvements in culverts for electric mains.** Fred Thornton and Latimer Clark, Muirhead, and Co., Limited, 24, Southampton-buildings, London.

February 5.

2225. **Improvements in the method of purifying electrolytes containing zinc, relating to or connected with the electro-metallurgic production of zinc.** Georg Nahnsen, 38, Alexander-strasse, Berlin. (Complete specification.)

2254. **Improvements in or connected with the holders of incandescent lamps.** William Phillips Thompson, 6, Lord-street, Liverpool. (Max Fuss, Germany.) (Complete specification.)

2260. **Improvements relating to the heating of metals by electricity and to machines therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (George Dexter Burton, Arthur Herbert Eddy, and George Sift Briggs, United States.)

2278. **Improvements in and relating to electroliers or pendants and standards for electric lamps.** Thomas Coombe Moore, 11, Southampton-buildings, London.

2283. **Improvements in systems of electric distribution.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Harry Ward Leonard, United States.)

2290. **Method or process of electric riveting.** Elias Elkan Ries 430, South broadway, Baltimore, Maryland, United States. (Complete specification.)

February 6.

2312. **Improvements in shade carriers for electric lamps.** Bernard Mervyn Drake, John Marshall Gorham, and James Saword, 66, Victoria-street, Westminster.

2329. **Improvements in process and apparatus for bleaching by electrolysis.** Oliver Imray, 28, Southampton-buildings, London. (Thomas James Montgomery, United States.) (Complete specification.)

2330. **Improvements in electric switches.** Edward Alfred Gimingham, 28, Southampton-buildings, London. (Complete specification.)

2336. **Improvements in dynamo-electric machines.** Hubert Doyer, 46, Lincoln's-inn-fields, London.

SPECIFICATIONS PUBLISHED.

1883.

2573. **Secondary batteries, etc.** Williams and Howell. (Second edition.) 8d.

1890.

6266. **Electrolysis.** Marks. (Second edition) 8d.

1891.

1804. **Electric motors.** Redfern. (W. Lahmeyer and Co.) 8d.
2732. **Electric lamps.** White. 6d.
3417. **Galvanic battery.** Munns. (Smith.) 8d.
4235. **Electric telegraph transmitters.** Fletcher. 8d.
4392. **Electrical bell, etc.** Entwistle. 8d.
4471. **Electrical switchboards, etc.** White. 6d.
4482. **Telephonic switchboards.** Prickett. 8d.
4678. **Electric terminals.** Pitkin. 4d.
4757. **Electric reduction of aluminium, etc.** Wilson. 8d.
4781. **Galvanic batteries.** Engledue. 4d.
4877. **Electric batteries.** Lake. (Street and another.) 6d.
5135* **Electric motors.** Southard. (Amended.) 8d.
5547. **Electrolytic decomposition.** Kellner. (Second edition). 8d.
10307. **Dynamo-electric machines.** Coeper. 8d.
19233. **Electric railways.** Munsie. 11d.
20936. **Electric heating.** Dewey. 8d.
21245. **Electric alarm, etc., clocks.** Clerc and others. 6d.
21870. **Voltaic cells.** Lake. (Clark.) 6d.
21961. **Relays, telephones, etc.** Lake. (Cuttris.) 8d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3½
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	23
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	1¼
Swan United	3½	4¼
St. James'	—	8¾
National Telephone	5	4⅜
Electric Construction	10	6¼
Westminster Electric	—	6¾
Liverpool Electric Supply	5	5
	3	2⅞

NOTES.

Stuttgart.—The central electric station at Stuttgart is to be opened this week.

Coventry.—This Council have adjourned the question of electric lighting for six months.

Telephone in Russia.—Gatschina, the summer residence of the Czar, is now connected by telephone to St. Petersburg.

Harwich.—A motion not to proceed with the provisional order has been deferred pending negotiations with the gas company.

Arcas Plating, which we recently described, has been applied with success to electrical, philosophical, and mathematical instruments.

Mr. Tesla's Lecture.—Mr. Tesla is to repeat his lecture on vibratory currents before the French Française de Physique.

Elmore in Austria.—It is stated that water power is being taken in Hungary for the establishment of an Elmore copper-depositing plant.

Yarmouth.—The borough surveyor has been authorised to visit the Crystal Palace Exhibition to examine the systems of lighting there.

Southampten.—The Baths Committee have authority to appoint an engineer, at a salary of £1. 15s. per week, to attend to the boilers and electric plant.

Northampton.—At the commemoration ball to celebrate the opening of the extension of the Town Hall, the electric light was utilised for decorative purposes.

Leamington.—The town clerk has been instructed to inform the Aurora Electric Company that no consent to its application for a license should be given.

The Snowstorm.—A fall of snow, making itself more especially felt in the North, this week cut off Leeds from telegraphic communication with London and the Continent.

Flying Machine.—A flying machine, on the model of the flying fox, driven by a 3-h.p. electric motor, has been built by Messrs. J. Shaw and Son, of Coventry, for Major Moore.

London Telephones.—The London County Council have decided to enter petitions against the Bills of the National Telephone Company and the New Telephone Company.

Regent-street Mains.—The London County Council have approved the laying of Siemens's armoured cable in Beak-street and Carnaby-street by the St. James and Pall Mall Company.

Cheap Fares.—The Lambeth Vestry have decided to oppose the Waterloo and City Railway Bill if the promoters do not insert a clause providing cheap fares for the working classes.

Standard of Light.—Prof. Vivian B. Lewes, F.I.C., F.C.S., of the Royal Naval College, Greenwich, has been appointed secretary of the committee for investigating the standard of light.

Nottingham.—A deputation from the Nottingham Town Council visited the Crystal Palace on Tuesday, and were shown round the exhibition under the guidance of Mr. W. H. Preece, F.R.S.

Hucknall Huthwaite.—A resolution has been passed that unless the application for a provisional order for gas lighting were at once withdrawn, the Board would light the streets by other means than gas.

Liverpool.—At the meeting of the gas company on Tuesday, the chairman, Mr. E. Lawrence, said that, in spite of high prices and the competition of electricity, the consumption of gas was steadily increasing.

Cardiff.—A meeting of the Cardiff Electrical and Lighting Committee was held on Tuesday. The question of lighting Upper Grange and Saltmead was further considered, and the borough engineer was requested to report thereon.

St. Olave's.—The St. Olave's Board of Works have approved of the objection offered by the Board of Trade to the application of the Camberwell and Islington Electric Light and Power Supply Company for a provisional order in the district.

Antwerp.—The system to be adopted at Antwerp, proposed by M. Van Rysselberghe, consists in distributing water at high pressure with turbine and dynamo in each house; in fact, the Popp system again, with water instead of compressed air.

Institute of Secretaries.—An institute of secretaries has been formed to act as a central body in the same way as institutes for other professions. The first general meeting was held last month at Winchester House, Mr. E. C. Wickes presiding.

Hawick.—On Monday night the High-street of Hawick was lighted with the electric light. The Corporation will continue the experiment for three months, and if successful, will adopt the electric light instead of gas. The experiment will cost £100.

Taunton.—The Committee of the Town Council has received an amended offer from the electric lighting company as to the purchase of that undertaking, and a sub-committee has been formed to consider the same. The report thereon is expected in March.

The Telegraph in Mashonaland.— Telegraphic communication was on Wednesday finally established between Fort Salisbury and the Cape. The first message which was sent over the wire was a congratulatory telegram despatched to London.

Magnetic Lines of Force.—The monthly meeting of the Edinburgh Mathematical Society was held last Friday in the Edinburgh Institution. Prof. Steggall, who presided, read a "Note on a Laboratory Method of Finding Lines of Magnetic Force."

Canadian Telegraphs.—It is stated on high authority that the Hon. J. J. Abbott will introduce in Parliament during next session a measure for the placing of the entire telegraphic system throughout the Dominion of Canada under Government control.

Paper Shades.—Besides the catalogue of glassware we mentioned last week, we have received from Messrs. Paterson and Cooper a finely-printed catalogue of paper and silk shades for electric fittings which should be of great use to electrical contractors.

Steamer Struck by Lightning.—An unusual occurrence happened lately to the steamer "La Congo," which experienced a fearful passage on the Portuguese coast, and in the height of the storm was struck by lightning, several of the passengers and crew being injured.

Technical Education.—The National Association for the Promotion of Technical and Secondary Education, of 14, Dean's-yard, Westminster, issue an urgent appeal to the electors of the London County Council for the greater extension of technical education for London.

St. Petersburg.—The exhibition at St. Petersburg seems to be bringing on business. Several Austrian firms, besides many French firms, are exhibiting, and it is stated that Messrs. Ganz have already received an order from St. Petersburg for a large central station plant.

Edinburgh Tramways.—A special meeting of Edinburgh Street Tramways Company was held on Monday for the purpose of considering a proposed Bill in Parliament to authorise the company to work their tramways by cable or electrical power. The motion was unanimously carried.

Telephones.—Messrs. Woodhouse and Rawson send us their price-sheets of telephones, transmitters for domestic and long-distance telephony, embracing wall sets, inkstand sets, desk-shaped sets, military telephones, and cheap domestic sets of great convenience for private telephone installations.

Electric Advertising.—Mount Washington is to be capped by the largest search-light in the world by railway and hotel men as a curious advertisement to draw visitors. It reminds us of our little tale, which was so seriously and widely copied, about the search-light beacon on Mount Kilimanjaro.

London Telephone Service.— A special general meeting of the London Chamber of Commerce is to be held on Monday, at 2·30 p.m., for the purpose of discussing the general position of the commercial community with regard to the telephone service of London, and the telephone Bills now before Parliament.

Wiring Houses in the City.—The City of London Electric Lighting Company have issued a circular embodying the general conditions to be complied with in wiring houses for the electric light. Pressure on our space prevents us doing more than refer to it this week. Copies can be obtained at the office of the company.

Hanley.—At the Hanley Town Council meeting, on Tuesday, on the proposition of the Electric Lighting Sub-Committee, it was resolved to advertise for specifications and estimates of the cost of plant and distributing mains and machinery for lighting by electricity the area contained in the second schedule of the Hanley provisional order.

Gigantic Electrical Trust.—A Dalziel's telegram from New York says that an electrical trust has been formed by the consolidation of the Edison Company with the Thomson-Houston Company. The capital of the trust is to be 50 million dollars, and the president will be Mr. H. M. Trembly. The new combination will be the only rival of the Westinghouse Company.

Sims-Edison Torpedo.—A large number of scientific men, with nearly all the naval and military attachés, witnessed the first public trial of the Sims-Edison torpedo at Portsmouth on Monday. Mr. Sims explained and worked the torpedo in person as on the previous private official trial. Further improvements are yet being made both in reducing the size of the weapon and of the cable.

Melbourne.—Separate tenders are invited by the Council of the City of Melbourne for the supply and delivery of (1) electric light plant; (2) cables and insulators. Tenders will be received until April 2nd, and must be addressed to the Right Worshipful the Mayor of Melbourne, Victoria, endorsed "Tender for ——" (as the case may be). Mr. John Clayton, town clerk, Town Hall, Melbourne.

Fleetwood.—The Lighting Committee of the Fleetwood Improvement Commissioners have resolved unanimously that the reports read upon the question of adopting the electric light in this district be received, and that the clerk be instructed to obtain from Messrs. J. E. H. Gordon and Co., Limited, further details with reference to the working arrangements of their installation, to be considered at a future meeting.

Kimberley Exhibition.—A meeting was held on Tuesday at the Society of Arts, when a paper on the proposed exhibition at Kimberley was read by Mr. Lewis Atkinson, the manager. Mr. Atkinson gave statistics and particulars of the progress of trade in Kimberley, with views of the town and country. The exhibition is well supported by the Cape Government, and the shipping companies will give cheap rates.

Parliamentary.—In the House of Commons on Tuesday, the Baker-street and Waterloo Railway, the Central London Railway, the City of London and South London Railway, the Great Northern and City Railway, the Hampstead, St. Pancras, and Charing Cross Railway, the London County Council (General Powers, Subways, Tramways) Bills, and other private measures were, on the motion of Mr. Caldwell, read a first time.

Pacific Cable.—Telegrams from Melbourne state that the New South Wales Government have agreed to grant a small subsidy for the proposed Pacific cable subject to a reduction in the tariff. The Victoria Government, however, is unwilling to grant a subsidy. The proposal is that the cable shall start from Gladstone, a little south of Rockhampton, in Queensland, go thence to Fiji, Samoa, and Honolulu, and finally touch at some point on the coast of North America.

Viator Resartus.—"On Saturday," a correspondent of the *Birmingham Daily Post* complains, "I travelled in one of the Bristol-road electric trams, and next morning found the backs of both legs of my trousers a bright red, evidently due to the action of acid or acid fumes. If you will kindly call attention to the matter, no doubt the cause will be enquired into." H'm! H'm! this gentleman now knows what Shakespeare meant when he spoke of "the imminent, deadly breech!"

Chicago.—Plans adopted for lighting the buildings and grounds of the World's Fair now provide for 138,218 electric lamps, of which 6,766 are to be arc lamps of 2,000 c.p. each, and 131,452 incandescent, 16 c.p. each. The electric lighting will cost something like 1,500,000dols., and will be 10 times as extensive as was employed at the Paris Exposition. The light and motive plant at the exposition, it is estimated, will require 26,000 h.p., of which 22,000 will be required for the electric plant.

The Madras Tramway.—In reply to the application of Messrs. Champion and Short, the local solicitors for Messrs. Hutchinson and Co., London, for the construction of a tramway in the Madras city, the Madras Government has directed that the order sanctioning the line be published, and that intimation be given that any objections or additions which anyone has to make thereto must be made by the 31st March. Orders in regard to the tramway proposal will then be definitely issued.

Transmission of Power.—An interesting instance of transmission of power for a paper mill has been recently started in Aachtthal, South Germany, for Herr Friedrich Kutter. The waterfall 1½ miles away is utilised by a Girard turbine. The motor, supplied by the Allgemeine Company, works at 800 volts, giving 80 h.p. at an efficiency of 79 per cent. Bare copper wires are used, with oil insulators. Another set of plant of 580 h.p. is also used, partly for lighting and partly for transmission of power for a number of purposes.

Fire.—We are sorry to record that the premises of the new and energetic firm, Messrs. Hodges and Todd, of 12, Verulam-street, Gray's-inn-road, were burst to the ground

yesterday morning. The firm have been quite busy with electrical fittings, especially ammeters and voltmeters, a considerable number of which were ready for delivery. The premises were insured, though not perhaps to the full amount. Immediate steps are being taken to carry on the work in other premises until rebuilding can be accomplished, and the work will be carried on as usual.

Arlecdon.—At the Arlecdon and Frizington Local Board the surveyor, in reference to electric lighting by water power, said he found the Millyeat stream would be insufficient in a dry season or hard frost. Recently an electrical engineer visited them from Leeds, and came to the conclusion that water power was not available. The matter dropped, but, perhaps, if it were suggested, a steam engine would do as well. Engineers other than electrical are not always wont to leave matters thus on occasions when water power is not available.

The Inventor of the Three-Phase Motor.—Mr. C. E. L. Brown, in a letter to the N.Y. *Electrical Engineer*, states his opinion that Tesla should be acknowledged as the true inventor of the three-phase motor as used at Frankfort, constructed by himself and Dobrowolsky. He draws attention to Mr. Tesla's patents for the three-phase current filed October 12, 1887, Nos. 381,968 and 382,280, and his further patent No. 390,414, filed April 23 of the following year, which conclusively show who was the true inventor of the three-phase current system.

Cable to the Azores.—A contract was signed at Lisbon on February 11th by the Portuguese Minister of Public Works and the representative of the Telegraph Construction and Maintenance Company for the laying of a cable between Lisbon and the islands of St. Michael, Fayal, Pico, St. George, and Tercira, in the Azores. The cable is to be completed in a year. In consideration of this contract it is expected that the telegraph company will be in an advantageous position to satisfy more adequately the requirements of the public between Europe and Brazil, and the United States of America.

Freight to Chicago Exhibition.—The British railways have undertaken to carry goods for British exhibitors at the Chicago Exhibition, to and from the port of shipment, at half rates. The American railways will charge their usual rates to Chicago, but will bring back the goods free at the close of the exhibition. Many of the principal steamship companies have reduced their rates considerably, and will take freight for the exhibition at 11s. per ton. Many of them have also consented to adopt a reduced passenger tariff for exhibitors and their employés, certified as such under the authority of the Royal Commission.

Explanations at the Crystal Palace.—Old Indian (meeting electrical friend): O.I.: "Ah! you are the very man I wanted to see. I wish you would tell me what electricity is, and all about it." E.F.: "Oh, certainly, with pleasure; but do you know anything of the subject?" O.I.: "Yes—a little." E.F.: "Well now, would you know a volt from an ampere if you saw one?" O.I.: "No—I think probably not." E.F.: "And if you found a kilowatt in an open 'field' would you know how to catch and use it?" O.I.: "I fear I shouldn't." E.F.: "Ah! I see. Well, if I should meet you here again another time I will tell you *some more*. Good-bye!"

Railway Parliamentary Committee.—It is proposed to appoint a joint committee of Lords and Commons to consider the numerous electric and cable railway schemes projected within the limits of the metropolis by Bills introduced this session. The duty of such a committee would be to report whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and probable future traffic, whether any of the schemes propose satisfactory lines of route, upon what terms and conditions the subsoil should be appropriated, and whether any of the schemes should be proceeded with during the present session.

Lightning Conductors.—An interesting paper on the above subject was read by Mr. Alfred Hands, F.R.Met.Soc., at the meeting of the Society of Architects last week. He insisted on the necessity for periodically testing conductors, and said that he had no hesitation in saying that at least 70 per cent. of the conductors in England were in such an unsatisfactory condition that they afford only partial protection, and damage might occur to the buildings on which they are fixed, while a large number were so absolutely bad that they would give no protection whatever. He also dealt with the question of when and where not to connect metalwork in buildings with conductors.

Obituary.—The death of Major-General Ryrie Alexander, late of the Bombay service, occurred at his residence, "Redwal," Dartmouth, Devon, on the 10th inst. For several years past it may be mentioned that Major-General Alexander had taken an interest in electrical matters, also in developing inventions relating to improved brakes and starters, with a view to reduce as far as possible the strain upon tramway and omnibus horses. He was a shareholder in several companies connected with the electrical industry, and for the past three years acted as chairman of Shippey Brothers, Limited. He had been failing in health for the past six months, prior to which he was engaged in perfecting an electric boiler feed-regulator.

The Aurora Borealis.—One of the finest displays of the aurora borealis ever known in this latitude was observed in New York on Sunday evening. Telegrams from various points show that the phenomenon stretched over a great belt of territory from Iowa to the Atlantic. A peculiar effect was produced on the telegraph system, and for intervals of three or four minutes at a time the wires were so surcharged with atmospheric electricity that between New York and Albany it was even possible to send messages without the aid of the regular batteries. The current, however, was intermittent. The aurora seemed to occupy the whole of the northern heavens, and was beautifully marked, the colouring being clear and distinct.

Brighton.—An item that should interest Prof. Forbes and other adherents of the use of destructors theory, comes from Brighton this week, where a lengthy discussion took place at the Town Council on a report from the Works Committee recommending the erection of a refuse destructor on a site adjoining Hollingdean-road. Councillor Lowther moved that the consideration of the same be deferred in order that the report might be made more complete. Eventually, however, the report was adopted. At the same meeting, on the recommendation of the Lighting Committee, the Council ordered additional electric light mains and distributors to be laid down in Church-street and through the Pavilion grounds and North-street.

Taunton.—The question of the purchase of the central station by the Taunton Corporation is still exercising the minds of the members. At the Town Council meeting last week, the Joint Finance and General Purposes Committee presented a report in which they stated that they had received an amended offer from the electric lighting company, and have appointed a sub-committee to consider the same, and the committee hope to be in a position to report fully thereon at the March Council meeting. The

committee are unable to accept the offer of the gas company to purchase the gas works, and the tendency, therefore, seems for the Corporation to run the electric light themselves against the local gas company. This will be "bad for the Co."

Electric Light for Wool Warehouses.—Messrs. D. C. Apperly, Carson, and Co., woollen warehousemen, 5, Cripplegate-buildings, and 13, Fore-street, have decided, after inspecting various installations and systems of electric lighting, to instal their own plant, consisting of arc and incandescent lamps, to be run direct from a gas engine and dynamo placed in the basement. The arc lights which are found most suitable are of a small size, so as not to be too glaring, and they are arranged on pulleys in such a manner as to enable them to be raised or lowered to any required focus, so that the most delicate colour may be successfully examined. All the lights have their independent switches, in order that each one may be turned off and on at will, and for examining goods special reflectors are being erected. The installation is being carried out by Mr. A. Bergtheil for the Wenham Company.

Notation.—*L'Industrie Electrique*, M. Hospitalier's new electrical venture, comes in handsome form with a series of interesting and original papers. The use of alternators with condensers receives mathematical disquisition; the standard of E.M.F. is dealt with, theoretically and elucidatorily, with special reference to the standard cell of MM. Baille et Fery; an article on improvements in accumulator practice by M. Roux does for France what Mr. Niblett has been doing for England; M. Laffargue also writes on accumulators; and M. Hospitalier has an article on the Parsons steam turbine. The French scientific societies are also reported. M. Hospitalier brings forward his own particular pet—electrical units and symbols—very strongly in an elaborate table of eight columns, and innumerable formulæ in the advertisement pages. The French for theory and the English for practice—and so the world wags.

Manchester.—The Manchester Central railway station was experimentally lighted by electricity last Friday. For the passenger department 40 Brockie-Pell arc lamps are provided, arranged in series, and elevated upon poles at the approaches, and in the station itself, suspended by wires from the roof. The lamps take 11 amperes each, in a 500-volt circuit, of which there are four. The various offices and the bookstall are supplied with 200 incandescent Edison-Swan lamps, each of 16 c.p. Edison-Hopkinson dynamos are used, and these, with the engines, which are of over 100 h.p., are placed in Trafford-street, from which point the communication is by cable. The installation for the goods department is not completed, but it is to be supplied with 70 arc and 60 glow lamps, the electrical arrangements being similar. The improved appearance of the station was the subject of general comment.

Electric Heaters.—Electric heating is coming along surely, though slowly. The editorial hat was ironed in a very workmanlike fashion the other day by one of the General Electric Company's electric heaters, and some electrically-cooked pancakes were distributed at the same time to a number of electrical devotees, who did not mind tampering with their digestion in the middle of the afternoon. The pancake, however, was cooked beautifully brown, and came to maturity in five minutes by the watch. The current was taken from an ordinary flexible and wall plug from a lighting circuit, taking three amperes and 100 volts for this space of time, and cooking three pancakes in series. Many householders in the flats around Kensington and Westminster would be glad enough of this cleanly way of *cooking*. Chops, we are told, can equally well be brought to perfection, and a kettle of water can be seen at any time at the Crystal Palace merrily steaming away.

Electric Communication to Lighthouses.—The members of the Chamber of Shipping for the United Kingdom dined at the Hotel Metrôpole last week, when Sir Michael Hicks-Beach was a guest, and spoke with reference to telegraphic communication with lighthouses and lightships. He said he felt it absurd to suggest that £100,000, or any such sum, would be sufficient, and that he had asked the Post Office to supply an estimate. Though he did not at all agree that the maintenance of lighthouses and lightships should fall upon the national exchequer, he felt that the provision of electrical communication would be a national service, and should be paid for out of the national funds. He was convinced that the country would not grudge a very considerable expenditure in such an attempt to save life at sea when fair and reasonable enquiry had been made as to how that expenditure might be most profitably incurred. The Government would propose to Parliament to make that enquiry.

Manchester Central Station.—Galloways, Limited, Manchester, have received the order for the six boilers and four large engines for the Manchester Corporation electric light installation. The boilers will be 30ft. long by 8ft. diameter, of ⅝in. steel plates for 125lb. pressure, and will be fitted with mechanical stokers as well as double sets of steam and feed arrangements. The engines will be vertical, 17in. and 34in. cylinders, 3ft. stroke, each to give off 360 brake horse-power (or 1,440 in the aggregate), with a piston-speed of 500ft. per minute, and will be provided with special arrangement of condenser. All have to be at work by the end of July. As regards the steam motors for this station, Messrs. R. Hornsby and Sons, Limited, of Grantham, have obtained an order for six tandem compound condensing vertical engines. These engines are to have 10½in. and 16in. cylinders with a 2ft. stroke, and will be constructed to give off 90 brake horse-power, with a piston-speed of 480ft. per minute. The consulting engineer is Dr. Hopkinson, of Victoria-street, Westminster.

High-Speed Electric Railways.—A note in the Institution *Journal* gives some figures by Herr Zipernowski upon his proposed high-speed electric line between Vienna and Budapest, a distance of 250 kilometres—say 150 miles. A speed of 150 miles an hour is proposed, which the author considers the maximum the wheels will stand with safety. The trains would consist of one carriage, seating 40 passengers, carried on two bogies with solid steel wheels 8ft. diameter, the driving power being four 200-h.p. motors, working at 1,000 volts, which necessitates collecting from a raised centre rail, some 600 amperes. The up and down lines would be 11 yards apart to avoid the shock of air when two carriages pass, blowing them off the rails (they ought to be cigar-shaped). There must be no curves of less radius than 3,000 metres—say, 1·8 miles—and for these the outer rail must be raised six inches. The power would be supplied from two stations by alternating current at 10,000 volts, transformed down to 1,000 volts, either using alternate-current motors or re-dressed to direct current.

Salford.—A deputation from the Salford Corporation and Gas Committee paid a visit on Saturday to the exhibition at the Crystal Palace. The deputation were accompanied by Mr. Shoubridge, engineer of the Corporation gas works. Under an order obtained from the Board of Trade, the Corporation are allowed until August next the exclusive right of controlling the supply of electricity for lighting purposes in the borough, and the inspection of the various types of plant now on view at the Crystal Palace has been arranged with the object of enabling the committee to make

some definite recommendation in the matter. It is thought probable that the Corporation will adopt the plan of inviting one or other of the lighting companies to take over their power and carry on the work for a specific period upon terms to be fixed in the contract. In this case the Corporation would reserve to themselves the right of taking up the supply, so that the interests of the ratepayers would in that way be fully protected. On their return to Salford the deputation will prepare a report which will be considered at the next meeting of the Gas Committee.

Liverpool.—At the weekly meeting of the Liverpool Watch Committee, on Monday, the consideration of the question of the city electric lighting was resumed. The Corporation at present have power to purchase from the Liverpool Electric Supply Company the undertaking comprised in the parliamentary order of 1889 at the end of 21 years; they can also acquire the undertaking authorised by the order of 1891 at the end of 42 years. Some time since the company applied for the consent of the Corporation to a provisional order enlarging the time within which the Corporation could elect to purchase the undertaking to 42 years—that is to say, for both undertakings. The committee have decided to recommend the Council to consent to the time being extended to 40 years on condition that the company agree to power being inserted in the order for the Corporation to purchase as a going concern both undertakings at any time after the 31st of December, 1897, upon giving 12 months' notice to the company to that effect. If the Corporation do not elect to purchase the undertaking under the proposed new powers, they will still be in a position to purchase the same at the expiration of 40 years without paying anything for the goodwill.

English Electrical Exhibits at Chicago.—Mr. W. H. Preece, F.R.S., as chairman of the Electrical Department Committee of the Royal Commission for Chicago, has written a stirring letter to members and manufacturers to urge that the electrical department should contain a fine exhibition from this country. An historical collection will be made (including, we believe, the first dynamo machine ever made and the original Atlantic telegraph instruments). A complete lighting station on English methods is contemplated. It is important to show how large a share Englishmen had in developing electrical science. The first electrician was an Englishman, Gilbert. The first practical telegraph was laid by Ronalds in 1816. Davy and Faraday, Cooke and Wheatstone, Wilde and Holmes were Englishmen. The first electric railway was run in England, and nearly all the submarine cables in the world were made here. The artistic developments are carried to a higher degree here than elsewhere. England is to the front with signals and high-speed telegraphy. It is to be remembered especially that large numbers of colonials will visit the exhibition, and England should not miss this opportunity of increasing her hold on colonial trade. Applications for space must be sent to the Society of Arts not later than the 29th inst.

Birmingham Tramways.—A deputation from the Corporation of Glasgow visited Birmingham on Tuesday for the purpose of inspecting the Central Tramway Company's systems of traction, and collecting information thereupon. Mr. Bailie Paton and Mr. D. Rankine, town clerk, headed the deputation. They were met at The Queen's Hotel by Messrs. W. Neale, director; W. Holmden, secretary; C. H. Herring, traffic manager; A. Dickinson, consulting engineer; J. J. Robins, electrical engineer; and R. H. Dickinson, local superintendent. A special car from Navigation-street conveyed them to the electric depôt at Bournbrook, where Mr. J. J. Robins, the electrical engineer, explained the system. They afterwards visited the cable depôt at Hockley, where Mr. A. Dickinson thoroughly explained the working. An amusing and dramatically successful incident occurred when the party entered the electric car at Navigation-street by a passenger (evidently mistaking the gentlemen for the directors) tendering his thanks to them for the splendid service they had provided on the Bristol-road. The deputation returned by the 4 p.m. train, highly pleased with what they had seen of the working of the electric and cable tramways in Birmingham, and expressed their gratification for the information afforded.

Dynamo Buyers.—Having said all they have to say upon the making of dynamo machines, some electrical engineers are taking to giving advice as to buying them. And probably this is not a bad thing to do. For if there is one thing certain in this world it is, that most men think they know their own requirements better than anyone else; and another thing almost as certain is, that very often this is just what they do not know. Now, the buyers of dynamos are to a large extent managers, proprietors, and engineers of works, who do not always know the points of a good dynamo. Instead of simply saying, "Ours is best," therefore, it pays to point out why. We published an article recently on choosing a dynamo, and we notice that another electrical engineer, after having built, bought, and described many dynamos, is also writing advice to dynamo buyers. His remarks embody some good points to indicate to a would-be customer. The dynamo should have stiff heavy standards, a heavy solid base with plenty of metal to give steadiness. The centre of gravity should be low—heating and springing of shafts are sometimes due to vibration. The speed should be low. It should have self-oiling bearings and convenient brushholders. The fewer the bolts and pieces, and the better proportioned the dynamo is as a pure machine, the better for the user; and all this in addition to its commercial efficiency and cost. These matters are all simple enough to the constructors, but it will pay to have catalogues and price-lists that dwell on these advantages for customers to note.

Leeds.—A strenuous letter has been sent on the electric lighting question to the Leeds newspapers from the following gentlemen: Reginald T. Hadow, for the Bank of England; E. Beckett Faber, for Beckett's Bank; Robert T. Haines, for the National Provincial Bank; Charles L. Mason, for the London and Midland Bank; E. Beckett Faber, for the Leeds Club; George Irwin, for the Leeds and County Conservative Club; Henry O. Harris, for Marshall and Snelgrove; as follows: "For months past we have been patiently waiting to take the electric light. Our patience has so far not been rewarded. Many towns of far less importance than Leeds have been long ago supplied with this light, and we cannot think it is the desire of our County Council to keep this, the chief town in Yorkshire, any longer in the background. We confidently call upon the authorities themselves to supply us with the electric light, or to allow terms to electric light companies sufficiently favourable to induce them to undertake the work. We do not ask the County Council to supply the light at an unremunerative rate, but at such a rate as will yield a fair commercial return. We venture to think that it would be a wise policy for the Council to recognise the established character of the electric light, and the desirability of supplying it concurrently with gas." This is a practical way for dealing with dilatory town councils, and should have a decided effect in waking up the authorities who have the central station scheme in hand. We notice in a later letter the agents of the Yorkshire House-to-House Company state that the prospectus of this company will be issued shortly, and comment with satisfaction on the likelihood shown of a large demand.

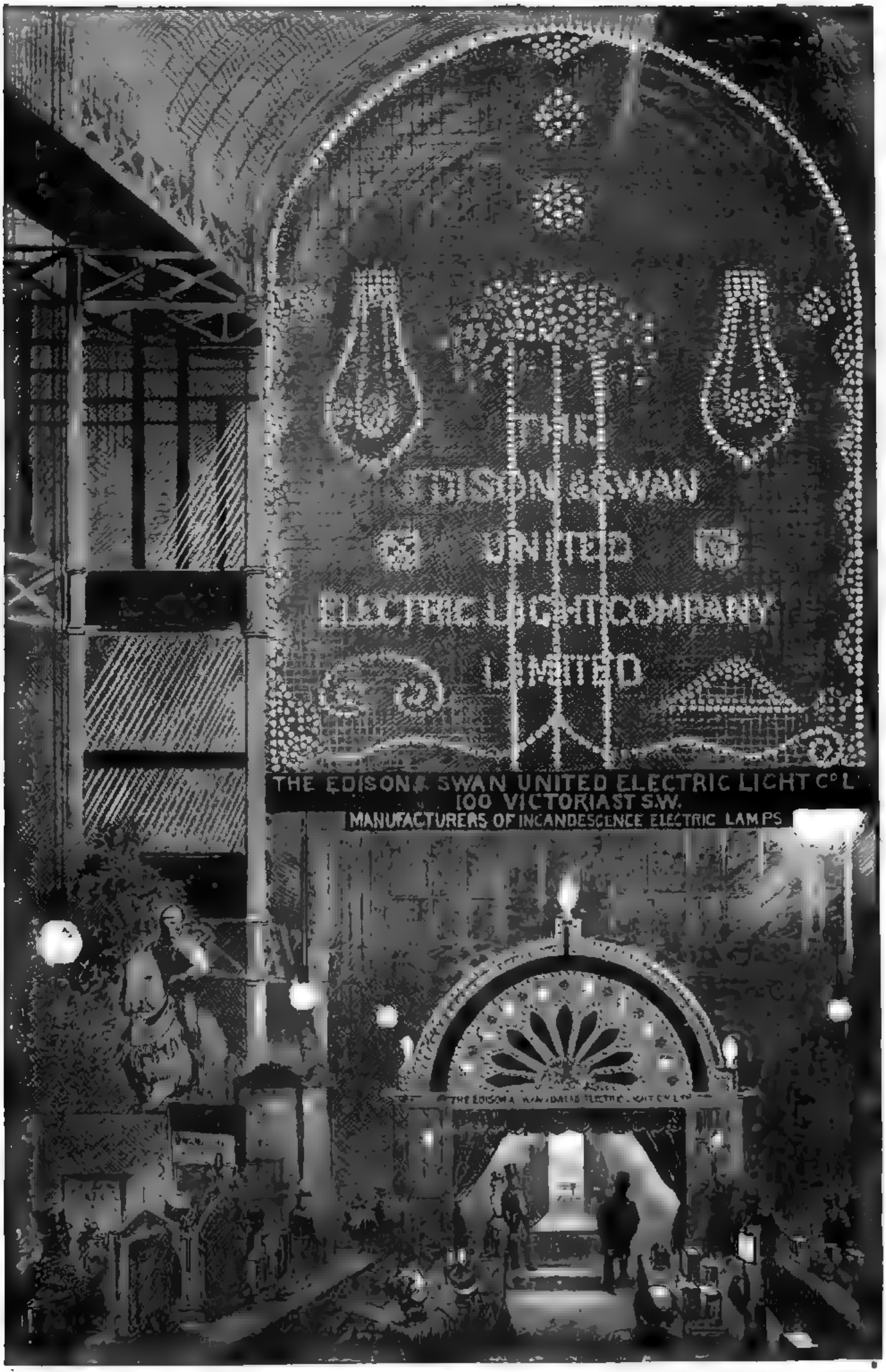
THE CRYSTAL PALACE EXHIBITION.

Mains and Transformers.

We have more than once referred to the energy shown by **Messrs. Gordon and Co.'s** staff in the matter of the central station at Sydenham, and the laying of the cables thence up to and in the Palace. We propose now to give a few details relating to the cable-laying, which will afford our readers some idea of what had to be done. Starting from the central station, three positive and three negative $^{19}/_{14}$ Fowler-Waring lead-covered cables, laid in Archer pipes, convey the electrical energy up to the Palace. The total length of cable is 11 miles, the route taken having been *viâ* those roads in which are the most likely houses to adopt the electric light hereafter. The number of cables will be increased by two positive and two negative, should the demand for light at the Exhibition require it. Where the cables enter the Palace there is a main switchboard, which allows any main to be switched off for testing purposes. Thence the mains are run inside the building to the primary switches of eight 40-unit transformers, the primaries being laid in cast-iron pipes. The pressure in the primaries varies from 950 volts to 1,030 volts, and is reduced in the motor-transformers to 100-110 volts. From the transformers four primaries and four secondaries (all $^{19}/_{14}$ Fowler-Waring lead-covered cable) are led to the centre of the Palace underneath the floor. Running down the centre of the building from the extreme north to the extreme south end, are a pair of equalising mains. Four positive and four negative cables from each transformer are tee'd on to these at equal distances, thus enabling leads to customers to be joined at any point without reducing the section of the main. Between each transformer on the equalising main is a straight through cast-iron fuse-box. Where customers are tee'd off the equalising mains, the feeding mains end in a cast-iron right-angled fuse-box, so constructed that the mains for the stands can be put through a 2in. cast-iron pipe, which fits into a socket in the top of the fuse-box, and is taken through the floor of the Palace. There are three miles of secondary cable ($^{19}/_{14}$) in the building. All the motor-transformers are worked in parallel on primaries as well as secondaries. The work of erecting and connecting up the transformers was only started in the second week of December; in fact, the whole of the cable-laying outside and inside the Palace did not begin until this date, leaving a bare month to complete everything for the Exhibition. Each of the motor-transformers weighs 6½ tons, and is placed in fireproof brick arches in the tunnel of the Palace, the said arches forming the support for the main flue of the building. The temperature in these arches must be felt to be realised. The space, too, is so confined that not even elbow room can be obtained all round the machine. These transformers had to be hauled into position by manual labour on skids over half the length of the Palace in a dark tunnel, where even with the aid of electric miners' lamps it was difficult for the workmen to see what they were doing. Moreover, the whole of the work, both cable laying and transformer moving, had to be carried out against time, the staff working practically night and day, seven days a week, to complete it. It is therefore very greatly to the credit of Mr. G. F. Metzger (under whose superintendence the work inside the Palace was carried out) and his staff, that Messrs. J. E. H. Gordon and Co. were ready on the opening day to supply current. It is still more to his credit that work carried out so hurriedly, and under by no means favourable conditions, should be found to stand without a hitch the test of practical running. We may mention that the work of laying the pipes from the central station to the Palace and the drawing in of the cables was superintended by Mr. C. Watkins, of Messrs. Gordon's staff.

Fire Precautions.

Here we may conveniently refer to the subject of precaution against fire. In the 1882 exhibition several fires broke out, and caused a considerable amount of alarm among the insurance offices. This time, however, we may hope that such accidents will be conspicuous by their *absence, for up to the present not* the slightest outbreak of the most trivial character has occurred, and yet, as a matter of fact, exhibitions like the present one are for many reasons the most difficult to secure against fire. To begin with, a large number of stalls are crowded together, many fitted with drapery and other highly-inflammable material; secondly, there is the difficulty of giving to what is, after all, but temporary work the permanence which would characterise an installation in an ordinary house or building; thirdly, the lighting of the stalls is done with a view to show off special goods, and consequently numbers of lights are employed in a space where only one or two would under ordinary circumstances be fitted up; and, finally, the whole of the wiring has to be carried out in the space of a few weeks—in fact, in a hurry. It is, therefore, no light work that Mr. Heaphy, C.E., of the Phœnix Fire Office, has had to undertake in supervising the whole of the wiring and installing in the Palace, and it speaks well for the confidence which the directors of the Crystal Palace have in his knowledge and practical experience that they should have invited him to supervise it for them. Of course, from the peculiar circumstances of the case, no hard-and-fast rules could be laid down; but it is satisfactory to know that Mr. Heaphy speaks in the highest terms of the way in which Messrs. Gordon and Co., the contractors for the supply of current, and the exhibitors generally have complied with his requests. It has been, in fact, a matter of give and take, in which on the one side it has been recognised that Mr. Heaphy's only desire was to obtain security against fire, while he, in turn, did not forget the peculiar circumstances of the case to which we have alluded above. The chief precautions adopted have been as follows: There is no network of conductors under the floor; all conductors are visible, and are attached to the metalwork of the Palace by porcelain insulators, the idea being that if a fire should unfortunately occur it should not be hidden away where it might smoulder and smoke, and from the fact of its magnitude not being able to be gauged, inspire alarm. A visible fire can be grappled with at once, its dimensions seen at a glance, and it need not as a rule cause much uneasiness even among lookers-on. Wherever possible, all the wiring at the stalls has been encased, and where it could be done without interfering with decorative effects this casing is made visible. Mr. Heaphy has also tried as much as possible to treat each stall as a separate private installation, provided with double switches and cut-outs at or near to the point of entrance of the conductors. In the event of a fire occurring, therefore, at any stall, the Palace staff of attendants would know at once what to do, supposing the stallkeepers were absent—viz., turn off the double switch before applying water. No conductors that have been used before have been allowed, and all must be insulated with vulcanised indiarubber. We have given details above of the work of laying the mains from the generating station to the Palace, under the flooring to the motor-transformers, and thence beneath the entire length of the building. What may not be generally known, however, should be mentioned here—viz., that the floor of the Palace is some 10ft. or 12ft. above the earth in which these mains are laid, and that the earth is wonderfully dry. The consumer's wires are taken off in a cast-iron pipe, through a cast-iron junction-box provided with double cut-outs, one for each wire going into the consumer's stall. Indeed, having regard to the special circumstances and difficulties of the case, the wiring arrangements have been excellently well thought out, and have been rendered as safe as they possibly can be made. In fact, although our experience of this class of exhibitions dates back to the first that was ever held, and includes all that have followed, we do not remember one in which the character of this work, as a whole, anything like equalled that at the Crystal Palace. We congratulate Mr. Heaphy on the result, not forgetting that he has been well backed up and cordially assisted in his endeavours to minimise fire risk by Messrs. Gordon and Co. and the greater part of the exhibitors. We should, perhaps, mention that the Phoenix Fire Office are taking no risks at the Palace, especially as it is well known that the rates have been raised by those offices who do take the risks during the continuance of the exhibition. In face



Edison-Swan Company's Lamp Screen and Stand at the Palace.

of the facts detailed above, and seeing that the wiring and installation work has been carried out under the supervision of a man of such well-known experience as Mr. Heaphy, we altogether fail to see the reason for this action.

THE SCREEN OF LAMPS.

The exhibit of the **Edison-Swan Company** in the North Nave calls to mind the state of affairs, 10 or 11 years ago, at the world-awakening exhibition at Paris. It was there the incandescent lamp broke upon the monotonous discussion of the "division of the light." Our gas contemporaries often refer to the division of opinion amongst electric light engineers. How they used to laugh and chuckle over the diverse opinions about the "division of the light," and intimated that such division was beyond the powers of inventors to devise! But Swan came along in England and Edison in America, both patenting a more or less perfect incandescent lamp, of small candle-power, admirably adapted for interior lighting, and thenceforward it became merely a question of time as to the introduction of such lighting. Few people seem to understand that the natural development of such an innovation is in the first place as a luxury, then, like other fashions, permeating downwards. It was partly due to this lack of knowledge that led to the insane speculative boom of the early eighties, but boom or no boom the luxury was appreciated, and gradually became more and more patronised. The tendency of the extensive use of most things is to reduce prices and increase efficiency. The use of the incandescent lamp has been no exception to the rule. Its cost is now lower and its efficiency greater than it ever was; and as soon as the existing patents run out and the monopoly expires, the price will be still lower. The Edison-Swan Company is not only manufacturing incandescent lamps, but also fittings of all kinds, and in this notice we shall pay more attention to the latter branch than to the former. Before, however, speaking of these we must describe the screen of lamps exhibited, and which our artist, Mr. W. M. Bowles, has delineated in the accompanying sketch. In almost all exhibitions there is some one exhibit which stands out prominently, catching the eye of the visitor, and impressing its effect upon the memory. It will not be too much to say that the *pièce de resistance* of the 1892 Crystal Palace Exhibition will be found in this screen of the Edison-Swan Company. In years to come visitors at other exhibitions will ask, Did you see the Edison-Swan exhibit at the Palace? As an advertisement, then, we hold it to be effective; as an advertisement it was intended, so that it effectively fulfils its design.

There are no less than 32 feeding cables used for the lighting of this screen, which, when its full complement of lamps is on, takes 1,500 amperes of current. The lamps are divided among five circuits, known by the respective devices into which they are made up as the "Border," "Name," "Fountain," "Lamps," and "Star" circuits. The screen is manipulated from an overhead platform erected for this purpose on some of the girders of the building. Here are the switchboards and numerous switches required to effect the rapid changes from one device to another which have proved so attractive to visitors to the Exhibition. There is a main switch for each of the above five circuits, which take about 300 amperes. Each of these circuits again can be split up into 10 of 30 amperes each, by which means a large combination of devices can be arranged.

The usual method of working is, first, switch on the "border" circuit by working the small switches one at a time, until the whole device is complete. Next, all the small switches of the "name" circuit are put down, and the whole of the "border" switched out at the same time as the "name" is switched on, the operator putting down the main switch for the one circuit with one hand and pulling back the other main switch with the other hand, so that the change is instantaneously effected, and the load remains the same. Another circuit is then made ready by the putting down the small switches, and the change made as above described, and so on until the whole of the devices have been shown. The total number of tumbler switches in use is 50, besides five large switches for the device circuits, and two for the main circuit. The filaments of the two "lamp" devices on either side of the screen each have a switch by which either of the filaments can be cut out and flashed alternately—a very pretty effect. We need not go into exact statistics as to the number of lamps employed on the screen. Electrical engineers will be able to estimate the quantity from the current used, but non-technical readers may like to know that the total runs up to thousands. Each of the main device circuits has its ampere-meter, whilst a Cardew voltmeter enables the attendant to see that his pressure is all right. A telephone is provided, by means of which those on the platform can let those in charge of the transformers know when they are going to light up.

Underneath the screen is a handsomely constructed room, the sides of which are fitted with specimens of the company's manufactures, as is also a stand and table running down the centre of the room. Opposite the northern entrance is a very taking exhibit, consisting of a very large lamp globe, the interior of which is filled with about a thousand incandescent lamps of all sizes, shapes, patterns, and colours, being specimens of all the lamps made by the company. Here and there along the filament of the containing lamp, small lamps are lighted to show the direction and position the filament in such a large lamp would take. The right-hand exhibit entering from the north consists principally of fittings, among which will be noticed shades, ceiling roses, switches, etc., some of which we now illustrate. A porcelain ceiling rose and fuse is shown. From this, more often than not, a flexible double wire carries the pendant lamp. The lamp may be ornamented from a variety of shades or globes, some of which are illustrated herewith. A form of fitting and lamp which we understand is largely used, but which we do not admire, takes the form of an imitation candle, as shown. Some of these candle lamp stands are of polished brass, others of porcelain. Their use is illustrated in some of the decorated interiors at the south end of the Palace. The screw and centre contact fittings for these imitation candle lamps are shown in the illustrations, as are the B.C. holder and insulator.

For table decoration we get the fairy lamp shades, and the visitor will revel in a variety of other fittings, which for the present we must leave.

A striking and varied exhibit in the Centre Transept of the Crystal Palace is that of the **General Electric Company**, a large pyramid or column formed of thousands of switches, cut-outs, ceiling roses, and wall plugs, surmounting a large assortment of the most varied electrical fittings, with motors, electric cookers, telephones, and so forth, flanked with large mirrors. The General Electric Company (whose managing director is Mr. Gustav Binswanger) are very widely known as manufacturers and suppliers of almost innumerable fittings for the use and application of electricity in one form and another, more particularly electrical light and telephones. They are more especially wholesale makers, and deal only with the trade. They have many specialities in which they have introduced new features, and in porcelain fittings of "high insulation" type they have some admirable features. They are the English agents for the now celebrated Aron meter; they make large numbers of large switchboards, and in telephony have introduced many efficient appliances, while the domestic utilisation of electricity has always had their special attention. At the Exhibition their goods are shown more for display than for explanation to every passer, so that although such features as the use of motors for shoe-brushing and so forth, and the use of heaters for making pancakes (which we shall describe in a future number), appeal strongly to the visitor, yet the mass of their exhibits are for technical men, electric contractors, and architects. Prominent among these fittings, of course, are switches and switchboards. Some of these we illustrate herewith.

The "Link" switch for mains or branch wires is an extremely good type of switch for ordinary use, for either large or small currents. It is of the rocking handle or "tumbler" type, but has a peculiarity in the link action, which, when the handle is pulled back, either locks the contact in place or springs it off with a sudden break. As will be seen from the illustration, a contact bar, pressed up strongly by spiral springs, has a little loose link in its centre. This is connected to the bar of the handle. When the handle is pulled back the bar is forced between two stout split contact springs, and so makes contact. The contacts for the cables, instead of being of

the type where the conductor is twisted round and pressed under a nut, is made of a hollow socket, admitting the conductor, in the case of the main switch, from the back, having side-set screws for binding the cable. The main Link switch is made in sizes from 50 up to 1,000 amperes, in heavy gunmetal. The same principle is applied to smaller switches, which are made in two sizes, to carry five and 10 amperes, suitable for 1—8 and 1—15 lamps. The main switches are made with slate bases, the branch switches usually in porcelain, with either porcelain or brass covers.

simply in a collection of different switches with their cut-outs mounted usually in a glass case, as shown. Almost all modern buildings are now fitted with some such system as this. Except private houses, where the owner may prefer to have separate switches on the walls of the room or in the holders, it is more usual to turn on all the lights from a distributing switch; and in public offices, banks, and large buildings, a man having charge of the key of the case goes round before dusk and turns on the switches.

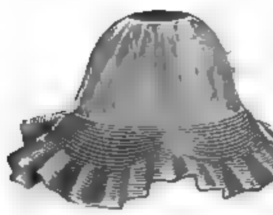
The "H.I.," or high-insulation, system of fittings, which

Ruby Spun Shade.

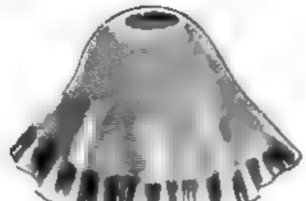
Opalescent Ribbed Shade.

Fairy Lamp Shade.

B.C. Holder for Candle Lamp.



Opalescent Shade.



Opal Shade.

Fluted Egg-shaped Globe.

Insulator for Candle Lamp.

Centre Contact Collar Candle Fitting.

Screw Candle Fitting

Porcelain Ceiling Rose.

Lamp imitating Candle.

Ceiling Rose with Fuse.

Pendant Lamp with a New Spring Shade Carrier.

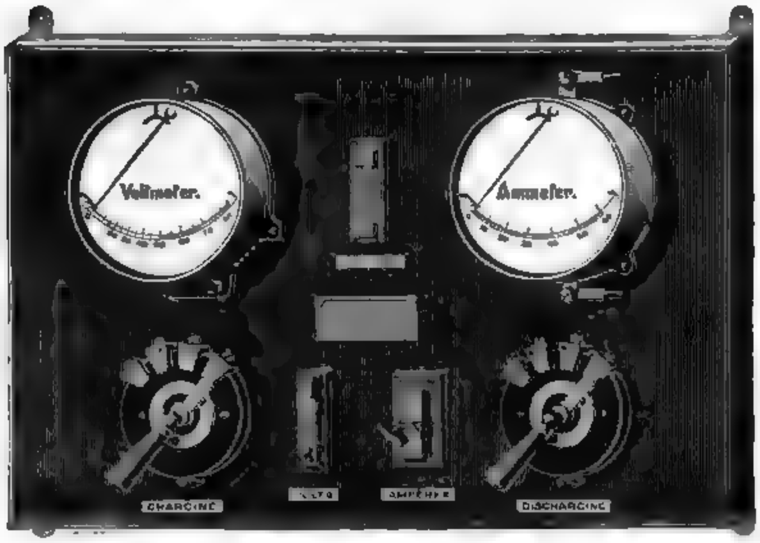
The "Link" switch is comparatively new, but another type, to which the name of "Byng" switch has been given, has been in use for many years. It is a double-break switch, and is made in a variety of patterns, plain or ornamented, and painted in artistic fashion, as shown in our illustration. They are also shown with brass covers.

The General Electric Company make up numerous varieties of switchboards, using their switches, ammeters and voltmeters, and cut-outs mounted on slate bases. A new type of switchboard now much in use is the corridor switchboard, used for lighting buildings which are connected to the street mains of a central station. It consists

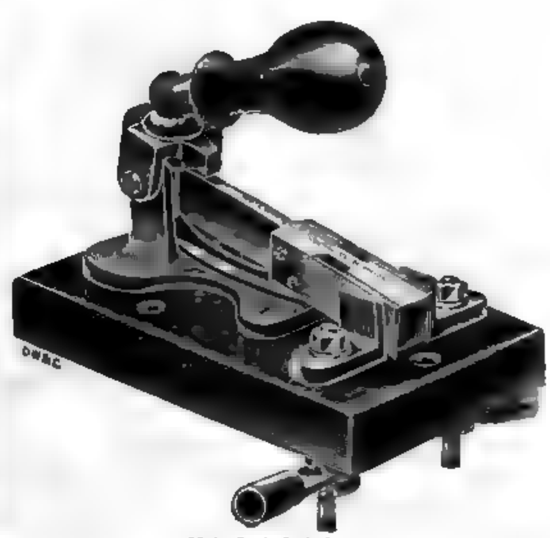
the General Electric Company have introduced, consists in the adoption of special precautions in the china bases of wall plugs, ceiling roses, and cut-outs—always the most troublesome part of the installation. In all the fittings on the H.I. system there are these special safeguards: A wall or plug of china divides the two ends of the flexible wire; and no screws, or metal, or other connections pass through to the back of the base-plate. The first prevents the loose ends of the flexible from making a short circuit, and the second prevents any dampness in the wall from affecting the insulation.

The wall plug on the H.I. system is shown in our

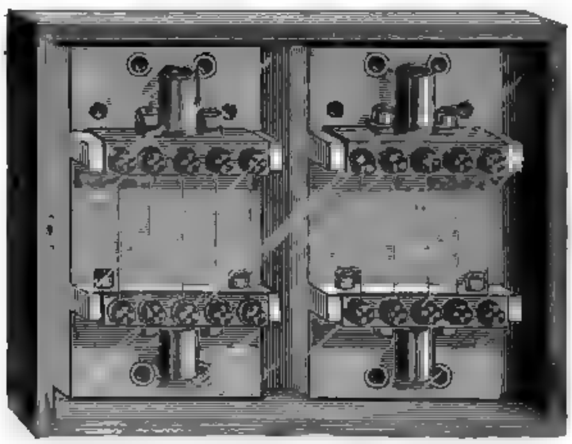
illustration, and embodies some further improvements. The great difficulty in wall plugs is to get them to fit together at once, and also to prevent all sparking. This is difficult to obtain in the two-prong type. That shown is made with concentric contacts, and fits easily and at once into place, with no danger of sparking. There are, moreover, no projecting prongs to get in the way. As will be seen, the socket has a split ring standing out in air, in the centre being a split pin. The plug fits on this, and makes contact with its stem inside and out. These wall plugs are very strongly and substantially made, both as regards the china and the contacts. It must be remembered that being



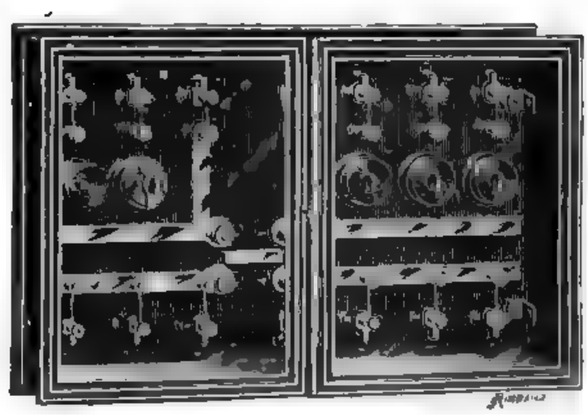
G. E. C. Accumulator Switchboard.



Main Link Switch

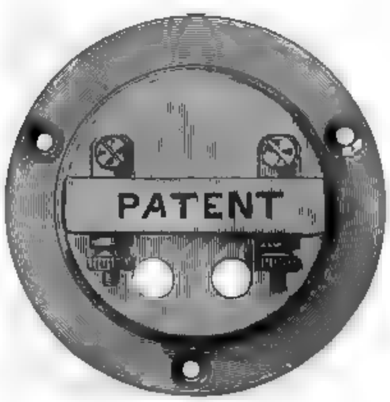


G. E. C. Distributing Board.



Modern Corridor Switchboard.

Ceiling Rose. "H.I." System.



Cut-Out. "H.I." System.

Ornamental Ceiling Rose.

Electric Light Standard.

movable they are at the service of everyone, and are used to connect a lamp, a chandelier, a motor, or a heater, and often have to carry five times their usual current.

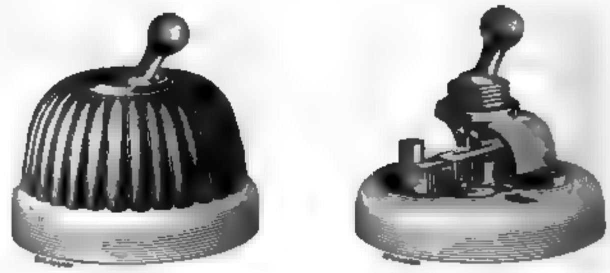
The "H.I." ceiling rose is also upon the same patented pattern. All the connections are on the front of the base, as seen in the illustration. The flexible comes through the holes in the plate, and the wires go one to the right and the other to the left of the porcelain T-piece. This fitting also embodies the principle strongly advocated by the makers of these fittings, that any fitting from which the current is led by a flexible, should have a cut-out. These places are more liable to short-circuit than any other position, and each should have its cut-out. In all these

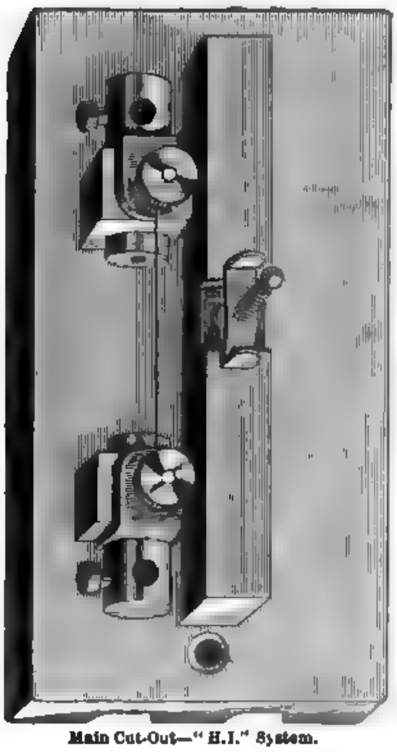
to separate the different wires of the flexible, which are connected to terminals at each side of a china partition. Another pattern of lampholder with the same kind of china socket is used for the loop lamps with spring holders.

The General Electric Company show also a number of ammeters and voltmeters made on the Donnison principle in their Manchester works. This principle depends upon the fact that an electric current passing circularly or spirally in a helical coil produces an interior magnetic field of varying strength—*i.e.*, the nearer the side of the core of the solenoid the stronger the field, the centre having the least number of magnetic lines passing. Any piece of iron pivoted eccentrically will tend to move into the stronger


Ordinary House Switch


Ornamental Switch.


Small "Link" Switch.


Main Cut-Out—"H.I." System.

Donnison Ammeter.


Holder for Loop Lamp.

Donnison Voltmeter.


Concentric Wall Plug—"H.I." System.


"H.I." Lampholder.

fittings, therefore, cut-out screws are inserted, and being there contractors generally put the fuses in.

The separate cut-outs on the "H.I." system are also shewn. In these the wires go straight through the block and are connected to screws, the screw passing through the separating porcelain piece, and the cut-out or fuse wire is inserted on the opposite side. These cut-outs are made both single and double pole, and also combined for a distributing-board. In the distributing-board now much used for the separate floors of houses, the main comes to one pole and the branches are connected to the others, the fuse wires stretching between.

In the bayonet lampholder, known as the "Belsize" holder, china supports are made on the "H.I." principle

magnetic field. In the Donnison instruments a piece of best charcoaled iron, carefully annealed, is pivoted eccentrically with regard to the axis of the solenoid, so that it will tend to move radially from right to left with regard to the centre of the solenoid and the face of the dial, carrying an aluminium pointer with it, from the left to the right hand. The movement of the pointer is controlled by gravity. The advantages of these instruments are that a scale can be obtained that is well proportioned, and between any two divisions of the scale at which the instrument will be usually working, the movements of the pointer can be greatly magnified. The resistances of the voltmeters are self-contained up to 300 volts. For higher reading instruments separate resistances are provided.

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THE "JOURNAL OF GAS LIGHTING" v. ELECTRIC LIGHTING.

The calling a spade a spade has usually been considered an attribute of bluntness rather than a characteristic of politeness. It is as impolitic, however, to hit a burglar with a cane when a bludgeon is handy, as it is to encounter some critics with soft words. Our contemporary the *Journal of Gas Lighting*, full of mistaken zeal, animated by the appearance of truth, arrogates to itself a weekly censorship of all that concerns electric lighting. It has for years so imposed upon itself by endeavouring to pick holes where none exist, that at length it has reached the critical period of assuming the facts and fancies of its own imagination to be realities with a tangible existence. It has so long been forming conclusions upon half-truths, that it has lost the power to dispassionately discuss whole truths. Last week a challenge was thrown to "electrical contemporaries," which at first we felt indisposed to take up unless the gas journal better defined its own position, but acting upon our motto that whoever is not aggressive ceases to be progressive, we will consider the merits of the case. The gas journal takes the figures of Colonel Makins given at the meeting of the Gas Light and Coke Company, and says: "We should esteem it a favour if our electrical contemporaries would let us and the world know their opinion of these figures, taken in conjunction (say) with Mr. W. H. Preece's remarks about the marvellous effects that have followed the introduction of electric lighting into the Post Office." Mr. Preece has again and again given the figures relating to the actual cost of the Post Office lighting, and also the fact that since its introduction the average absence through illness of the employés has been shortened—figures and facts that are official, which have not and cannot be impugned—so that we may safely leave this part of the challenge till our contemporary disputes the accuracy of the official statistics. The figures of Colonel Makins are in a different category. We assume their correctness, and give reasons for the deductions we derive therefrom. The following we presume are the figures referred to by our contemporary. We take them from the *Times'* report :

"They had very carefully looked into the electric light question as it affected them. The most important electric lighting district was formed of what he might call the Bond-street quadrilateral—Bond-street, Regent-street, Oxford-street, Piccadilly, Pall-mall, and the Strand. Their rental from that district in 1889 was £77,675, when the electric light was more than beginning to make itself felt; and in 1890 the amount fell to £74,947, and last year to £73,538. They had thus lost in a district which was more electrically lighted than any place in the world £4,000 of rental in three years, while the increase in their rental all over their district for last year alone was £92,000. He might say further that they had got out a list of typical consumers in every part of their district—the Houses of Parliament, Marlborough House, the British Museum, the General Post Office, banks, clubs, places of amusement, and large tradespeople;

and he found, dealing with this list of eighty-one consumers, that the rental which they paid the company three years ago was £91,363, two years ago the amount was £88,323, and last year it was £87,847. This showed, again, that they had lost £4,000 in three years among all these great consumers of the electric light. He thought they had conclusively proved that the electric light was a light of luxury, and was used only by those who did not care about the question of cost. He might say that out of their 215,000 or 220,000 customers only 2,600 used the electric light, or less than 1¼ per cent."

According to these figures, Colonel Makins and our contemporary assume the total loss due to competition to be £4,000 in three years. That is a convenient assumption, and very gratifying to the gas interest. Why, then, should we envy them the pleasure they derive from the consideration of these figures? We should not take the trouble to show the incorrectness of their conclusions were it not for the challenge they themselves throw out. Our contemporary must think it has to deal with a lot of unsophisticated people, if it hopes to obtain credence in its conclusions. It will be seen that Colonel Makins speaks of this district as a most important lighting district; hence, we may safely assume that the consumers are large consumers, and upon this we are asked to believe that 2,600 consumers only spent £4,000 per year upon lighting during a period of three years—that is, just over 30s. per consumer per annum. Upon the face of it, this is utterly ridiculous. The way to arrive at the true loss would be to collect all the bills these 2,600 consumers paid for electric light, and the total amount would give the loss to gas. It is needless to discuss whether a man pays more for the electric light than he does for gas. If he gets what he wants from gas, he is ready to pay the same price as for electricity. From what we know of the district under discussion, we should imagine the collective bills of 2,600 consumers would be nearer £50,000 over three years than the amount assumed by our contemporary. As we have hinted before, this gas journal delights in half-truths, or the untruth which is more difficult to encounter than the downright whopper. Let us try these figures another way. According to one of the experts at the meeting, if the gas company's affairs were properly conducted there ought to be an increase in consumption—say of 7 per cent. since 1889. Now, if we accept this dictum, the income in 1891, instead of being £73,538, should have been about £83,000—a difference of £10,000, not of £4,000. We have no wish to be hard upon our contemporary, nor do we desire to show up in detail its rather blind rushing after inferences. It will be sufficient for our present purpose to indicate how different an interpretation can be placed upon the figures given by Colonel Makins than that intended when they were put forward. Surely in this case the moral will be learned, that in future it will be better for those interested in gas to deal with generalities and trivialities, rather than to give figures which may be used t'other way. This humble advice, by the way, is not offered to our gaseous contemporary, because it long ago showed that it would heed no morals and draw no inferences but those which happened to suit its particular purpose.

CANTOR LECTURE—No. 4.

The last lecture of this series of Cantor lectures was delivered by Prof. Forbes on Monday last. The lecturer dealt with two interesting subjects in the utilisation of water power and the use of destructors for electrical purposes, taking his text with regard to water power from the experience at Geneva, where turbines are used on the Rhone with a fall of water of only 6ft. to 12ft. to pump up water to a higher level. This high-level water is that used to actuate the machinery of the town, and although the central lighting station is near the low-pressure turbine station, the power used in the station is that supplied from the high-level reservoir. To drive home his moral, Prof. Forbes suggested what might be done at Edinburgh. Assuming a maximum output of power required at the central station of 1,000 h.p. for two hours as being the same as an average continuous output of 150 h.p., he pointed out that the existing loch on the top of Arthur's Seat, at Edinburgh, would about provide water for 1,000 h.p. for two hours, and could be made to give double this by the erection of a by no means objectionable dam. To keep the head of water required, engines of 150 h.p. would be used to pump, and pipes led back to the central station to bring the water to actuate the turbines. In other words, Prof. Forbes's scheme for lighting Edinburgh is to pump up water to the loch on Arthur's Seat by engine power, to use the water so pumped to drive turbines which would drive the generators, and he states that his estimates show this to be an economical plan. It may be remarked that 1,000 h.p. would not go far towards lighting Edinburgh. At the most you might obtain 7,000 16-c.p. incandescents, or 14,000 8 c.p. This, again, might allow the wiring of 70,000 of the one, or 140,000 of the other, if we assume that only one lamp in ten is using current. It may, however, be safely stated that this proportion is too small. The lighting of Edinburgh would require more horse-power than was mentioned in the lecture, but no doubt Prof. Forbes only referred to that part of his scheme connected with the special point he was urging on his hearers. A description of the "destructors" in use by various local authorities was next given, Prof. Forbes concluding that the destructor in Kidacre-street, Leeds, was the best he had examined. A certain amount of heat generated in these destructors can be usefully employed, and Prof. Forbes's moral was contained in the suggestion that a combination of the Geneva plan with the utilisation of the heat from the destructor would in many cases be found economical. Thus, supposing 150 h.p. could be obtained from the destructors, engines of this capacity could be continuously pumping water into a high-level reservoir. The water so pumped could be used by the central lighting station for its turbine, and a maximum of 1,000 h.p. obtained for lighting purposes for the

busiest hours of the lighting day. This combination will be new to many electrical engineers. We think more mention might have been made of the excellent experimental work of Mr. Bennett at Southampton. In 1889 Mr. Bennett read a paper before the Municipal Engineers explaining how he had used, and proposed further to use, the waste heat from the destructors at Southampton. We have occasion also to know that the use of destructors has been carefully examined by other electrical engineers, and more than one local authority is at the present moment discussing schemes founded on a use of this apparatus. Prof. Forbes's lecture will prove useful in causing more general attention to be given this subject.

UNDERGROUND MAINS.—XI.

JOHNSTONE'S CONDUIT SYSTEM.

The Johnstone system of electric conduits has long been in use for underground mains in some of the principal towns of the United States, such as New York, Philadelphia, and Chicago. There are already over 150 miles of cable laid on this system, 111 miles of which are in New York. The system is now being introduced into England by the International Electric Subway Company, of Albany-mansions, 39, Victoria-street, Westminster, where a complete and full-sized installation is to be seen; and as it seems to be an eminently practical system suitable for large companies, and especially for corporations wishing to keep control of their streets and subways, we make no apology for describing it in our series of systems of underground electric mains.

The essential idea of the Johnstone system is the use of ordinary insulated cables in cast-iron conduits of such a nature as to allow many sets of mains or wires to be laid together without being confused, and to allow of jointing for distribution at any point with the minimum disturbance of the roadway. The conduit is made entirely of cast iron, produced without machine work, and is, therefore, especially for large distribution networks, of economical cost.

The conduit is built up, piece by piece, in the form of a cast-iron trough, composed of two sections, laid one upon the other, the edges being tongued and grooved, and when laid in the streets, jointed with putty or cement. In the interior of the trough so formed, trays of cast iron are slid in, each tray bearing on its upper surface grooves into which separating slips of cast iron are also slid. In this manner continuous ducts are formed to the number desired, into which the cables can be laid or drawn. In order to give the utmost facility for jointing, this cast-iron troughing is made in 5ft. lengths, and at any place a section cover can be lifted and a jointing piece or spigot can be inserted for distributing or service mains. In practice the two sections, top and bottom, of the trough or conduit are laid so as to break joint; a joint therefore comes at every 2½ft. The troughs are kept in position in the simplest way by lugs cast on the sections, which interlap, and are fixed simply by knocking in a wedge.

To ensure joints being water-tight, all grooves, recessed clamps, and abutting ends are filled with putty. With this joint the longer it is immersed in water the harder the joint becomes. The reliability of this method for making a water-tight joint has been tested by long experience.

Distributing-boxes or hand-holes are placed opposite every building or party wall, but this not done usually until the conduit is complete. The pavement is dug up and the conduit first laid in blank, so as not to necessitate the trench being made larger at any one place. When the time comes to connect the house, the blank cover is removed, and a specially cast cover with spigot is inserted. In this way the wires can easily be got at, either to repair, test, or join up house services. All the covers are interchangeable, and if, needed, the connection with the main can be made from the underneath. The spigots can be turned round and the joint made from either right or left hand side as desired.

Manhole of the Johnstone Conduit System.

At central positions such as the intersections of streets, a large pit is dug and an iron manhole is built. This iron manhole has been adopted both as being very substantial

and preventing the introduction of moisture. The manhole is built up of various circular cast-iron rings, grooved and jointed as are the troughs. These rings are of several sizes, and some are made with openings for connecting to the conduit itself. These are termed the spigot rings, and it can be seen that such an arrangement allows the mains to be taken off at any height and in any direction with the minimum of previous arrangement or trouble. The spigot rings are all of uniform size, and various-sized conduits are made to fit the same size of spigot. Above the last ring of the manhole is placed a tapering hood, or top, made of sufficient strength to take the strain of the street traffic. The manhole is closed first by a cover to exclude moisture, and above this by a grooved foot-plate laid flush with the level of the street. The manholes are very large, and it might, perhaps, be possible to place transformers in them in certain positions. The rapidity with which the manholes can be built up and the conduits laid along the streets is evidently a point in its favour.

Johnstone Electric Conduit System.

The illustrations we give are taken from work as actually carried out in New York. Any cables can, of course, be used—ordinary insulated, concentric, and for light, power, telegraph, or telephone.

In connection with the Johnstone conduits there are three points to which particular attention is directed—(1) facility for distribution, (2) accessibility, (3) the use of cast iron throughout.

The Johnstone system is especially convenient for distributing wires at any point in the circuit because of the sectional structure of the conduit, which enables a junction-box to be inserted at any time by simply removing a 5ft. section and replacing it by another supplied with a hand-hole opening or distributing-box. This feature is very advantageous in street lighting, where it is often necessary to make joints at points not provided for when the mains were first laid. It is equally easy, as is seen, to distribute from the top or bottom, or from either side.

In making a joint at the hand-hole used in this system, provision is made for laying the necessary splices out of the direct line of the conduit which contains the cable, thus avoiding any danger to the splice, which naturally increases the size of the cable at that particular point. This device consists of the projecting casting or spigot attached at the time the connection with the house is made. It extends outside the line of the conduit, and prevents the possibility of any injury being done to the splice by a push-rod for the purpose of drawing in other cables in the same duct.

The second feature in the Johnstone system is its accessibility. As it is impossible to insulate wires with such perfection that defects will not occur at some time or other in a conduit carrying a high-tension current, the question arises how to do the necessary repairs at the least cost, and with as little delay as possible. One of the great advantages of the 5ft. sections is that in the case of a defective wire, the exact position of which is known, the 5ft. top section can be removed, if necessary, all the partition shelves taken out, and the cables that are in use allowed to swing or suspend from their respective ducts over the open place; the cable can then be repaired. This operation disturbs only the defective cable, avoiding the laborious and expensive work of drawing the cable out from one manhole to another. After the repair is made the partition shelves can be slid into their original position, the cables adjusted in their ducts, and the top section replaced, making the conduit equal to its original condition.

In most devices for underground conduits the only way a cable can be reached for repair, after it has once been laid, is by removing bodily or drawing out the damaged cable, the former necessitating the expense of digging up the street or pavement from manhole to manhole, or whatever the distance may be.

In any pipe system of conduits the fact of screwing one pipe into a union joint, or any device used as the equivalent of a union joint, is very likely to throw upon the inner surface of the pipe sharp edges which are liable to cut or damage the insulation of the cable when it is being drawn in. This is avoided by the use of the ducts.

The sections are perfectly fitted together, so that each line of ducts forms a smooth uninterrupted casing through which

cables can be drawn without the possibility of injuring the insulation.

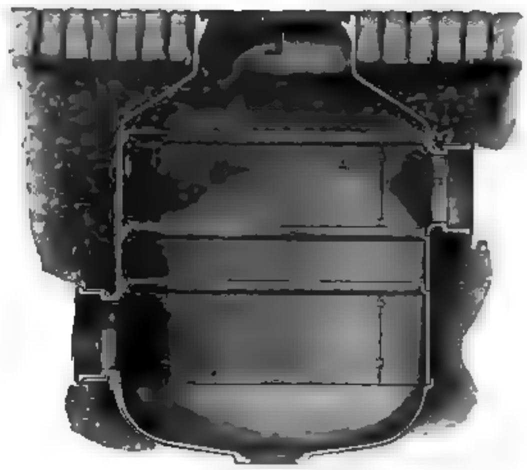
This construction, moreover, conforms to the present Board of Trade regulations—viz., that when high and low tension mains are carried in one conduit the cable must be entirely surrounded by a metallic conductor and each have its own compartment. Lead-covered electric light cables in an insulated conduit are regarded as highly dangerous. Assuming that a conduit is constructed of an insulating material, and that the cables are lead-covered, the lead covers of these cables are in such a case conductors, each one of which might be charged to a very high potential. Such conditions would prevent jointers doing their work with any degree of safety, and would make underground work much more dangerous than overhead.

These conduits have been down in America and in use for over five years, and are understood to have given great satisfaction.

The conduits are manufactured in different sizes to meet the requirements of electrical services of various descriptions, and in price they compare favourably with the methods now in use.

HORIZONTAL VIEW

TOP VIEW



VERTICAL SECTION OF MAN-HOLE

SIDE VIEW
SHOWING OUTLET OF CONDUIT

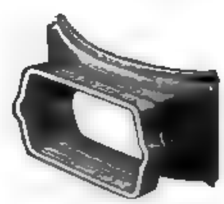
Type	A A	has	24	ducts	with an area of	235	square inches.		
,,	A	,,	16	,,	,,	,,	150	,,	,,
,,	A½	,,	8	,,	,,	,,	64	,,	,,
,,	B	,,	9	,,	,,	,,	52	,,	,,
,,	C	,,	6	,,	,,	,,	41	,,	,,
,,	D	,,	4	,,	,,	,,	29	,,	,,
,,	F	,,	2	,,	,,	,,	18	,,	,,

Types F and G are cylindrical cast-iron pipes, 3½in. by 6in. respectively in diameter; the pipes are cast in two equal longitudinal parts, they are grooved and fastened together with keys and wedges. They are in 5ft. sections, and furnish the same facilities for distribution and access as the larger types, and like them have a perfectly smooth inner surface.

The Johnstone system of electrical underground conduits evidently provides for every requirement of electrical underground service in any desired quantity and of every description—viz., telegraph, telephone, electric light, electric power district messenger, and fire alarm service, the cables and wires of which are all times accessible at any point along the line of structure.

We understand that negotiations are in progress for the immediate laying down of a set of distributing conduits on this system in a large English town which is intending to introduce the electric light.

PERSPECTIVE OF A² CONDUIT
SHOWING HAND-HOLE AND SPIGOT
AND ARRANGEMENT OF DUCTS



SEGMENT OF MIDDLE RING
WITH OUTLET FOR A CONDUIT

A 

A² 

SEGMENT OF MIDDLE RING
WITH OUTLET FOR G CONDUIT

B 

C 

SEGMENT OF MIDDLE RINGS
OF MAN-HOLE

D 

E 

Details of Manhole and Conduits in the Johnstone System

Electricity in the Workshop.—A fine example of the extended use of electric motors for all manner of purposes in the engineering workshop is given in a recent description (February 3rd) in the New York *Electrical Engineer*, with illustrations of the Edison Schenectady works—power-house, electric crane, electric derrick, electric hoist, electric blower, electric elevator, electric shunting locomotive, motors driving drills, pumps, lathes—the electric railway round the works, and the boiler-shop, all run by the universal electric motor. These are the kind of instances that convert practical engineers to belief in the *motor*.

A DESCRIPTION AND COMPARISON OF THE METHODS OF ELECTRIC LIGHTING AT PRESENT IN USE IN LONDON.*

BY ALEXANDER B. W. KENNEDY, F.R.S., M.I.C.E., ETC.

(Continued from page 165.)

The "transformer" used with alternating currents is based on the following phenomena: If two conductors of a suitable kind, and forming part of closed circuits, are placed near together and parallel, but without any contact (that is, completely insulated from each other), and a current be passed through the one, at the instant of starting it a current will be found to traverse the other. This latter current (which is called an induced current) does not continue, whether or not the originating current goes on steadily; it is instantaneous only, occurring just at the instant of starting. But at the instant when the first or primary current ceases, another induced current appears in the second wire, this time in the opposite direction to that in which it formerly appeared. If, therefore, the primary current starts and stops 80 times per second, the induced or secondary current will be a similar discontinuous current having the same frequency and therefore available for the same purposes. If the primary and secondary wires be alike, the tension of the two currents as well as their quantity will be the same. By using, instead of a straight wire, the helix of a certain number of turns to form the primary, and for the secondary another helix containing a different number of turns, the induced current may be made either higher or lower in pressure than the primary. The quantity of current, of course, varies inversely as the pressure, so that the amount of energy transmitted is not altered, except so far as internal losses affect the efficiency of the apparatus. In principle the transformer is simply a pair of coils such

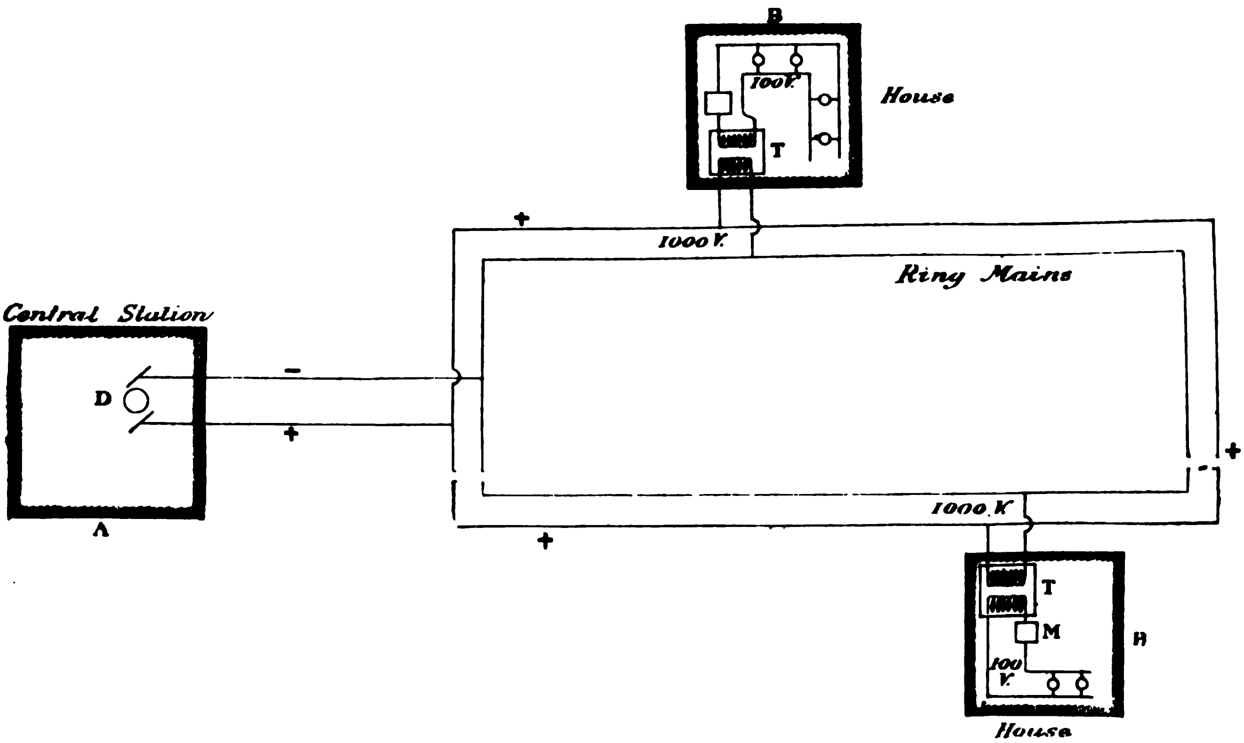


FIG. 1.

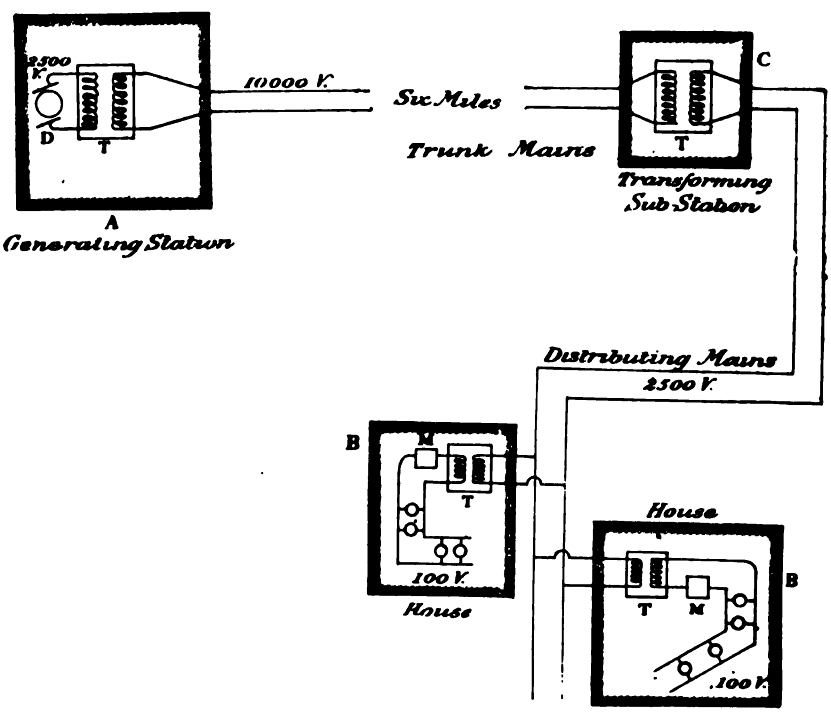


FIG. 2.

* Reprinted from the *Transactions* of the Royal Scottish Society of Arts, vol. xiii., part 1. Read May 11, 1891.

as I have mentioned. Remember that there is no electrical contact whatever between the coils, although they may be in very close proximity. The high-tension main goes from the station to the primary coil of the transformer and back again to the station without actually entering the house. The low-tension main goes from the secondary coil of the transformer round the house circuits. Apart from accidents, therefore, the high-tension current can never actually get into the house mains. Fig. 1* shows the general arrangement of the circuit and transformers used by the Metropolitan Electric Supply Corporation. A is the central station from which a series of circuits are led through the district. D represents a dynamo, with its two poles connected to one of those circuits. It will be seen that soon after leaving the station both positive and negative wires are looped into rings; the ring may, of course, embrace many streets. B B are houses in the district to be supplied with current. There is a transformer, T, and a meter, M, in every house. Wires from the mains enter the transformer, pass through the primary coil, and come out again. The secondary coil is shown separately connected with the lamp circuits of the house. The meter by which the electric energy is measured is on the house circuit. The pressure in the mains is 1,000 volts, the pressure in the house circuits may be either 100 volts or 50 volts, according to the wish of the consumer. Mr. Frank Bailey, the engineer to the company, is of opinion that a 50-volt house circuit is better than a 100-volt house circuit, from the view at any rate of the life of the lamps. The system of looped mains shown in the sketch is due to Mr. Bailey, and has been adopted so that every house on a circuit can be reached round the loop in two ways, thus greatly reducing the risk of breakdown through an accident on the mains. One or more circuits may be connected to and worked from the same dynamo at the station, but at present it has not been found possible here to put more than one dynamo on to the same circuit, or, in technical language, to run the dynamos in parallel.

The system adopted by the London Electric Supply Corporation, which has been from the commencement designed and worked out by Mr. Ferranti, differs from that just described in very many respects. Its general scheme is sketched in Fig. 2. This company has, rightly or wrongly, assumed that it was advisable to make its station away from London. Its generating station is on the Thames at Deptford, about six miles from Charing Cross. Current is there generated by large dynamos at a pressure of 2,500 volts. It is transformed at once up to 10,000 volts, and transmitted to London at that pressure by specially insulated mains of most ingenious construction. These mains lead to two or three sub-stations in London itself, one in Bond-street, one near Charing Cross, etc., which contain transformers only, and where the current is transformed down to 2,500 volts again, and distributed at this pressure through the streets. In the customers' houses it is transformed down to 100 volts, just as in the last case. It is intended ultimately to generate current at the full pressure of 10,000 volts so as to save the first transformation. There can be no doubt that with such appliances and knowledge as we possess at present the drawbacks of having three transformers are very great indeed. Whether or not they are more than counterbalanced by the advantage of having a station down the river is a matter which must finally be decided by the result of practical working.

The system used by the House-to-House Company does not differ in essentials from that of the Metropolitan Electric Corporation, except that the pressure in the mains is 2,500 volts instead of 1,000.

I have said above that the transformer was the trouble as well as the blessing of the alternating-current system. Whilst it enables a saving to be made apparently throughout the whole of the mains, this saving is accompanied not only by the very notable cost of the transformers, but also by such a very great loss in efficiency that it is now most improbable that any new high-tension company will be started in an urban district on any of the plans I have described—that is to say, with a transformer in the house of each customer.

(*To be continued.*)

* *The same lettering is used in all the figures.*

ELECTRIC TRAMWAYS ON THE OVERHEAD OR TROLLEY WIRE SYSTEM.*

BY W. GIBSON CAREY.

The idea of propelling vehicles by means of electric motors does not appear to have received any serious attention until about 50 years ago. In 1840, Henry Pinkus, of Philadelphia, applied for and obtained a patent for a system of electric propulsion of vehicles, which closely resembles both the open-conduit and the double-trolley systems. He proposed to use a continuous slotted tube or conduit, supported alongside the track and containing two conductors, from one of which the current was to be taken by a sliding contact and suitable connecting conductor to the motor on the car, and through the other of which it was to be returned to the generating station. It need hardly be said, however, that owing to the imperfect state of the motors of that day, nothing practicable came of this scheme.

Some experiments in electric railways were tried in Berlin in 1867 by Dr. Werner Siemens, but it was found that the Siemens machine as then constructed heated excessively, and the work was temporarily abandoned. In 1879, however, the same experiments were resumed with more successful results. In that year Messrs. Siemens constructed a line 500 metres in length at the Berlin Exhibition. The main conductor in this case was a central rail, the outer rails completing the circuit back to the generating station. Prompted by the success of this venture, similar attempts were made at Brussels, Dusseldorf, and Frankfort with equal success, and two years later Messrs. Siemens put down a permanent line at Lichterfelde, near Berlin. While the Siemens were engaged in their experiments in this direction, Charles J. Van Depoele, Steven G. Field, Thomas A. Edison, and several others were working on the same lines in America, and at the end of 1882 a railway, which was the result of eight years of constant experiment, was put down by Mr. Van Depoele at Chicago. After this Van Depoele, Daft, and the Bentley-Knight Company built roads in quick succession at Toronto, Baltimore, New Orleans, Cleveland, and many other places. But in spite of the rapid progress that was made, as a result of the experience gained on these installations, it cannot be said that the electric railway became a practical commercial success until 1888, in which year Bentley and Knight built the Allegheny City road, the Sprague Company equipped the road at Richmond, and the Thomson-Houston Company, who had by then acquired Van Depoele's patents, built the Eckington and Soldiers' Home road in Washington. On January 1st of that year there were in operation in the United States 13 electric tramways operating 98 motor cars, on less than 50 miles of track. Three and a-half years later the country could show 354 roads, operating 4,513 motor cars, on nearly 3,000 miles of track. During the last six months fully 50 more roads have been added to this list. Such has been the growth of electric traction in four years.

In Europe, on the other hand, the rate of increase has shown scarcely any improvement. A new area of progress appears to be opening now. Several Siemens roads, and the great Bremen system, which is to be equipped throughout by the Thomson-Houston Company, in Europe, and recent installations in England, promise to be the nucleus of a list of electric tramways on this side of the Atlantic, which will before very long rival in importance those of the United States. The early inventors first turned their attention to open conduits, and as long as the lines were purely experimental ones, constructed on private grounds over which there was no general traffic, and which was already thoroughly drained, there appeared to be no difficulty in maintaining the conductors in satisfactory condition. As soon, however, as it was attempted to apply the conduit to conditions of actual practice, unforeseen difficulties arose from the impossibility of excluding dirt and moisture. In the United States alone, at least four practical experiments have been made in this line, and many thousands of pounds expended in efforts to construct railways upon this principle. The difficulties with which each attempt met naturally turned the attention of the pioneers to overhead wires, which were found to be entirely

* **Paper read before the Royal Engineers.**

free from the objections to which the conduit was open. Æsthetic considerations, however, forbade the adoption of a system involving lines of poles and overhead wires in public streets, until every means of avoiding it had been tried and found inadequate, and again and again inventors returned to the search for some method of underground transmission of power. The experience, however, of Van Depoele, Bentley and Knight, and many others, has left us little reason to hope that a continuous live conductor in an open-slotted conduit can ever be made a success in our city streets, its fatal weakness being the impossibility of keeping the conduit free from mud and water.

Much thought and labour have been expended in the attempts to produce a system of closed conduits, having an insulated main conductor with a series of points or plates upon the streets surface, which are brought into contact with the main conductor one at a time as the car passes over them. None of these schemes have been extensively tried, but it is scarcely possible to look for anything but failure as the fate of any of them, unless some scheme can be devised where the insulation of the live parts can be maintained. This has not yet been done. Even if dependable automatic devices prevent the contact points from being in contact with the main conductor all the time, if the conduit is filled with mud and water, and the points are made alive during the passage of the car over them, there will be a momentary grounding of these points, and the result will be, if perhaps not so severe a grounding as that to which the open conduit is liable, at least one bad enough to cause fatal disaster both at the power station and on the line. If such a system as this can be perfected, the field for electric traction will at once be enormously widened, for it cannot be doubted that many communities are deterred from adopting it only by their prejudice against overhead wires.

Attention was early given to the propulsion of tramcars by means of accumulators, but although improvements have from time to time been made in the batteries, by which greater weight, efficiency, and longer life have been secured, the cases in which the storage battery car can render satisfactory services are few and far between. The load diagram of an electric car in actual service on the curves and gradients which it must encounter in our city streets shows such enormous variations, that provision must be made for the supply of fully seven or eight times the average current consumed. A car which nominally will take 7 h.p. or 8 h.p. may momentarily require, when starting on a heavy grade, 60 h.p. or 70 h.p. Motors of half of this maximum capacity can readily stand such unusual demands when made for only a few moments at a time, but no battery that has as yet been devised can stand anything like this rough usage without very rapid deterioration, and it is impossible to supply the requisite amount of surplus power in cells without adding prohibitive weight. Ample experience has proved that the storage battery has not yet, commercially at least, been brought to that point at which it can successfully meet the requirements of anything but absolutely level lines, and these in urban tramways are scarce indeed. It is of course earnestly to be hoped that the efforts of those men who are working in this direction may soon be crowned with success, and no one will more gladly greet the advent of a practical storage cell than the manufacturing companies who are exploiting the trolley wire.

Even the practical American at first objected to the erection of poles and the stringing of wires through the streets, but the necessity for rapid transit which became greater and greater as the growth of the cities made it necessary for business men and workers to live further and further away from the places of their employment, made some substitute for the slow horse-car an absolute necessity and they early saw that the choice lay between rapid transit with overhead wires and the expenditure of valuable time in travelling back and forth between their business and their homes without them. The installations at Boston, Washington, and Richmond (Va.) called the attention of street railway officials throughout the country to the cleanliness, reliability, flexibility, and economy of the overhead electric system, and the opportunity which it offered them to supply the public with rapid and comfortable transit at a reduced cost was at once eagerly embraced upon an enormous scale. Great pressure was brought to bear upon local authorities and upon public opinion, and local consents were quickly obtained in every city of importance throughout the country. The patents of the principal inventors, which until then had been owned by a few men of small capital and little influence, had by this time been taken up by large and very rich corporations, and upon these orders now began to flow in for tramway motors at a rate which severely taxed their output capacity. European conservatism and the fact that the advantages of electric traction have not been properly brought before the public have up to now prevented its adoption on a very extensive scale. As has been pointed out, this conservatism and apathy are now beginning to give way, and we may soon expect to see the advantages enjoyed by the Americans within the reach of the citizens of many of the prominent towns on this side of the Atlantic.

This brief view of the various methods of applying electricity as a motive power for tramways has been necessary to show the reasons for the almost universal adoption of the overhead or trolley system. Experience has proved no point more strongly than the necessity for absolute thoroughness and as near an approach to perfection as can be attained, in both design and workmanship, of every detail. No class of machinery is subjected to more severe and constantly recurring shocks than electric tramway apparatus, and no detail, whether of power station, line, or rolling-stock can be too good, and nothing short of the best obtainable should ever be used. It is poor economy to instal cheap and flimsy apparatus, which will from first to last cause endless vexatious accidents and swell the repair bill to proportions that will far outweigh the interest on a more liberal investment.

In considering electric tramways, it is customary to divide the subject into and consider it under the following heads—viz., (1) the line; (2) the power station; (3) the rolling-stock.

Under the first of these come the trolley wire, the poles, span wires, or other devices used for supporting the trolley, the feed wire, and the track. With regard to the first, it was easily foreseen and early proved that the currents of large and varying volume, if returned to the generating station through the rails and earth, would cause considerable disturbances upon the neighbouring telephone lines using grounded circuits. In order to avoid this, a complete metallic circuit with two trolley wires, suspended side by side about 8in. apart, was constructed, and every effort was made to perfect a system built upon these lines. Very little trial showed the insurmountable difficulties, both electrical and mechanical, which such an arrangement introduced. In the first place the wires, supporting and insulating devices, etc., had to be made of double the weight of a single trolley line, and therefore required heavier span wires and larger and more objectionable poles. Again it was fonnd that without making the spans of the trolley wire exceedingly short, and therefore greatly increasing the number of poles, it was impossible to pull the trolley wire up tight enough to avoid contact between the positive and negative wires. Endless short circuits and accidents to the wiring, owing to its great weight and the impossibility of securely supporting it without the employment of cumbersome and inadmissable supports and insulators, soon made a return to the single trolley wire a necessity. The remedy for the interference with the telephones has been found in the adoption, in the case of the latter, of a complete metallic circuit.

It has been found that a trolley wire about ¼in. in diameter gives better results than any other size. On very many short roads, on which the number of cars operated is small, this is large enough to transmit the requisite amount of power without too great a loss in the line. Smaller wires were found liable to accidents from strains which this size can readily withstand, and a larger wire necessitates the use of objectionably heavy supporting and insulating devices, so that No. 0 B and S gauge has been adopted almost exclusively as a standard size for urban roads. This is drawn very hard in mile lengths, and wound with the utmost care upon very heavy reels. This careful winding of the trolley wires is of the first

importance, owing to the fact that any looseness causes kinks in the wire, which are only with great difficulty removed.

(To be continued.)

SOME EXPERIMENTAL INVESTIGATIONS OF ALTERNATE CURRENTS.*

BY ALEXANDER SIEMENS.

Most of the papers read before this Institution on the subject of alternate electric currents, and on apparatus employed for utilising them, have dealt principally with the theoretical side of the question, and undoubtedly have been extremely useful to constructors of alternate-current apparatus. Nevertheless, certain gaps in our knowledge obtruded themselves in practice, and the investigations and experiments which are described in the present communication were undertaken not so much to verify any particular theory as to increase our knowledge of useful facts.

For convenience of reference, these experiments are not described in chronological order, but they have been grouped together according to the subjects which they are intended to elucidate. Foremost among these is the loss of energy through the heating of iron by induction where alternate electric currents are employed—a subject which engaged the attention of Prof. Ewing and of Dr. J. Hopkinson six years ago, whose researches pointed out the direction in which further experiments should be made. It is well known that this loss is caused by the so-called Foucault currents and by hysteresis. The effect of the former is counteracted by laminating the core of a magnet either by building it up with wires of small diameter or with thin discs, according to the direction of the lines of induction.

A short consideration will show that the heat produced by Foucault currents can be calculated beforehand for a core of known construction and dimensions. Take the case of an iron wire, 1 cm. long, subjected to an induction parallel to its axis of B lines per one square centimetre of its section. Let r be the radius of the wire, and ρ the radius of a ring, of the width $d\rho$, concentric with the wire. In this ring currents will be produced in the same manner as in the secondary circuit of a transformer. The maximum induction passing through this ring is $N = \rho^2 \pi . B$. Hence the E.M.F. generated is $E = 4 n N \times 10^{-8} = 4 n \rho^2 \pi B 10^{-8}$ volts.

If c is the conductivity of the iron employed, the resistance of the ring is $R = \frac{1}{c} \times \frac{2 \pi \rho}{d \rho}$; consequently the waste of energy in this ring, expressed in watts, is

$$d W = \frac{E^2}{R} = 8 c \pi n^2 B^2 \rho^3 d \rho . 10^{-16}.$$

The total energy wasted in 1 cm. length of the wire is therefore

$$W = 2 c . \pi . n^2 . B^2 . r^4 . 10^{-16} \text{ watts.}$$

From this formula a cable has been calculated to indicate the waste of energy by Foucault currents in 1 cwt. of iron of the conductivity $c = 0{\cdot}102 \times 10^6$, when an alternate current of the frequency $n = 100$ complete periods per second was employed.

Induction. B	Diameter of Wire. ½ mm. Watts.	1 mm. Watts.	2 mm. Watts.	3 mm. Watts.
1,000	0·8	3·3	13·3	29·9
2,000	3·3	13·3	53·3	119·9
3,000	7·4	29·9	119·9	269·8
4,000	13·4	53·3	213·3	479·8
5,000	20·8	83·3	333·2	749·7
6,000	29·9	119·9	479·8	1,079·4

In order to determine the total loss of energy caused by the heating of the iron, experiments were made with a specially constructed "cable transformer."

This mode of constructing transformers has been foreshadowed by Dr. Werner von Siemens, who proposed in his patent No. 42 of 1886 to surround the primary and secondary circuits of a transformer with iron wire, but his experiments gave no satisfactory results. The subject was recently taken up again, and the present form of these transformers was suggested by Mr. Dieselhorst and Dr. Baur. The principal advantage which is claimed for this form of transformer is that it can be made by machinery in the same way as a submarine cable is made, the employment of manual labour in putting it together being entirely avoided.

A special machine has been designed and erected for completing such transformers in one operation, after the iron core has been prepared on an ordinary rope-stranding machine. Besides offering these facilities for manufacture, the peculiar shape of the cable transformer lends itself to a variety of useful applications. For instance, at the Crystal Palace Exhibition one of these transformers connects an alternate-current machine to a high-voltage transformer some distance away, raising the potential of the current at the same time from 80 volts to 2,500 volts. The transformer used for the experiments has a core of 900 soft iron wires, each 1 mm. in diameter by 6 metres long, twisted up in the form of a rope, and surrounded by two windings of copper wire, properly insulated, the one for high voltage and the other for low voltage. From the fact that the diameter of the transformer is very small compared to its length, it follows that the magnetic field, and consequently the induction in the iron core, is uniformly distributed, with the exception of a slight drop at either end.

The mean induction produced by passing an alternate current through the low-voltage circuit was measured by the difference of potential obtained in the high-voltage circuit while no current was passing through the latter. The temperature of the iron core was ascertained by measuring the increase in the electrical resistance of one of its wires, which had been insulated from the rest by a cotton covering. By actual comparison it was found that one of the wires near the periphery gave, within the limits of errors of observation, the same results as the central wire, so that the exact position of this "test wire" has no influence on the result; the heating of the cotton insulation can be neglected, as its mass is so very small compared with that of the iron.

Separate tests were made to determine the specific heat of the iron, which was found to be = 0·112, and the temperature coefficient for the electrical resistance of the test wire, which was equal to 0·0054. The current was kept on for a short time only, as it was desired in the first instance to determine the rate at which energy is converted into heat in such a transformer, and the rise in temperature after keeping the current on for s seconds can be calculated from the formula—

$$t_s = \frac{R_s - R_o}{{\cdot}0054 . R_o}.$$

R_o = electrical resistance before starting the current; R_s = electrical resistance after keeping the current on for s seconds.

During the time that the current passes, the test wire will lose a certain amount of heat by radiation and convection, although it is surrounded by all the other iron wires, which are heated in a similar manner. This loss can, however, easily be allowed for by plotting a "cooling curve" after the passage of the current has been stopped, with times as abscissæ and temperatures as ordinates. In this way the rise of temperature of the iron core per second was observed with an alternate current of 100 complete periods per second, varying in strength so as to produce a different induction for each observation.

Considering that the loss of energy caused by the heating of the iron is proportionate to its mass, to its specific heat, and to its rise of temperature per second, it was possible to plot a curve in which the maximum number of C.G.S. lines per square centimetre are the abscissæ, and the losses of energy are represented as ordinates calculated for the mass of 1 cwt. of soft iron wires 1 mm. in diameter.

It should be added that the abscissæ of curve 2, Diagram I., which embodies the results obtained, have been calculated from the measured volts, instead of from the calculated mean volts, which in sinoidal waves are = 0·9 measured volts. This was done as curve 2 was to be used for designing transformers where the measured volts only are used for calculation.

As this curve gives the losses caused by hysteresis and by Foucault currents, while the formula given above enables us to calculate the losses caused by the Foucault currents alone, we can determine the loss by hysteresis alone by a simple subtraction. All these results, it must be remembered, refer to 1 cwt. of soft iron, subdivided into wires of 1 mm. diameter, on which an alternate current is acting of a frequency of 100 complete periods per second, the type of apparatus used being a cable transformer. The following table shows the results:

Induction. B =	Losses of energy. Curve 2. Watts.	Foucault currents. Watts.	Hysteresis. Watts.
1,000	43·2	3·3	39·9
2,000	96·2	13·3	82·9
3,000	158·0	29·9	128·1
4,000	231·2	53·3	177·9
5,000	309·5	83·3	226·2
6,000	390·1	119·9	270·2

The losses caused by hysteresis are independent of the dimensions of the iron. This table enables us, therefore, together with the formula for the losses caused by Foucault currents, to predetermine the rate of the loss of energy in iron wire of any weight or dimensions when acted upon by an alternate current of a frequency equal to 100 complete periods per second. Similar experiments were made with alternate currents of a frequency of 66·6 complete period per second, and of a frequency of 133·3 complete periods per second, and the curves embodying the results are also shown on Diagram I.

It should be observed that the currents of 66·6 and of 100 complete periods were obtained from the same alternate-current machine (type W_1), which has a high self induction in the armature, and of which it has been ascertained experimentally that the waves of its current are sinoidal. The currents of 133 complete periods per second were produced by another type of machine (W_{11}) with a low self-induction and a very narrow field.

On Diagram II. the losses by hysteresis alone have been shown, derived from the curves of Diagram I. by deducting the losses caused by Foucault currents according to calculation. By way of comparison, Prof. Ewing's curve of losses caused by static hysteresis has been added. In this table the results obtained with alternate currents of 133·3 complete periods per second have been left out of consideration, on account of their being made with a different machine, as just explained.

The next point to be investigated is the change which an alteration of the frequency of the current will involve in the case of a transformer designed for a given voltage in its secondary circuit. If it is borne in mind that this voltage, apart from the constant factors, depend on the product n N (n denoting the frequency, and N the maximum number of lines of induction), it follows at once that in order to produce the same E.M.F. with a lower frequency, the number of lines of induction has to be increased in proportion, and *vice versâ*. In other words, if the

* Paper read before the Institution of Electrical Engineers, *February 11, 1892.*

same E.M.F. is to be produced in the secondary circuit of a given transformer, the product n N must be constant. This result can at once be applied to the formula, which gives the losses of energy caused by Foucault currents—

$$W = 2\,c\,\pi\,n^2\,B^2\,r^4\,10^{-16};$$

and as $N = r^2 . \pi . B$, the formula can be expressed—

$$W = \frac{2\,c}{\pi}\,(n\,N)^2\,10^{-16};$$

or, in other words, these losses are constant for the same transformer, whatever the frequency may be, as long as the E.M.F. of the secondary circuit remains the same.

A comparison of the curves for a frequency of 66·7 and of 100 complete periods per second on Diagram I. shows that the losses of energy for the same induction are practically proportional to the frequencies. The same curves show that this loss increases more rapidly than the number of lines of induction.

From this consideration, it follows that a transformer which has been designed to produce a certain E.M.F. in its secondary circuit with a given frequency cannot produce the same E.M.F. with a lower frequency without overheating, while it remains cooler when it is worked with a higher frequency. In other words, transformers built for low frequency require much material.

An experiment was made to ascertain the final temperatures of a 50-h.p. transformer worked with different frequencies, and after 10 hours' working the maximum temperature was found to be—for a frequency of 100 complete periods per second, 53deg. C. in the core, and 46deg. C. on the outside; for a frequency of 66 complete periods per second, 69deg. C. in the core, and 57deg. C. on the outside—a result which appears to bear out the above consideration.

What frequency is most advantageous can, however, not be settled by taking into account nothing but the heating of the transformers: it is quite evident that the construction of suitable generating apparatus plays as important a part; and the problem resolves itself into the commercial one, which combination of apparatus can be constructed most cheaply?

The question, what induction should be settled upon in designing a transformer, is rather a complex one, and it can only be solved by taking into consideration: 1st. The amount of material, iron and copper. 2nd. The drop of potential difference in the secondary circuit from no load to full load. 3rd. The efficiency of the apparatus. 4th. The heating of the apparatus.

In order to facilitate the investigations a series of transformers is compared which all have the same length of iron core, and the same number of turns of copper wire of the same diameter.

It is assumed that one of these transformers is designed for an induction B = 5,000, and that its output is such that the weights of the iron and of the copper used in its construction are equal to each other and to 1 cwt.; this may be called the normal transformer. If, now, another transformer of the same series, but with a lower induction, is to produce the same voltage, the section of the iron has to be increased proportionately: for instance, in the case of B = 2,500 it has to be doubled. The weight of the iron employed varies, in fact, inversely as the induction, and their relation can be represented by a rectangular hyperbola (curve 7). As we have assumed that the thickness of the copper wire and the number of its turns are to be the same in all these transformers, the weight of the copper will vary directly with the length of wire wound on the iron core, and this can be determined if the relationship between the length of periphery and the section of the iron core is known.

In the case of the sections of the cores being circles, or squares, or rectangles, with the same ratio between their length and width, the length of periphery varies as the square root of the section. As transformers are generally designed with cores of this kind, it may be accepted that the periphery of the iron core, and, consequently, the weight of copper to be employed, varies as the square root of the section of the iron core.

The weight of copper in the series of transformers under contemplation can therefore be represented by a curve (8), the ordinates of which are the square root of the ordinates of the curve giving the weight of iron for the corresponding inductions. From these two curves it appears that the weight of the iron increases very rapidly with decreasing induction, while the weight of copper increases at a slower rate.

(*To be continued.*)

ELECTRICITY APPLIED TO MINING—THEORY AND PRACTICE.

At the meeting, last week, of the North of England Institute of Mining and Mechanical Engineers, held in Newcastle, Mr. D. Selby Bigge read a paper on electrical engineering as applied to coal mining, with an account of the installation recently effected at one of the Earl of Durham's collieries.

Mr. Bigge, in the course of an exhaustive address, said the question of power transmission by means of electricity is by no means a new or untried one, and though, perhaps, little is known of the details as yet by the mining world in general, results have been obtained in actual practice which merit serious attention. Electricity has now been applied, and with great success, in mining work for haulage, pumping, drilling, coal-cutting, and other minor uses, and as in the case of electric lighting, electric power may now fairly be said to have passed out of its experimental stage, and to have become an accomplished fact. It is chiefly as a means for transmitting power to great distances with small loss along the line that electricity will be found to predominate over any other known form of power transmission, and as distance is usually a most important factor in mining operations underground, electricity in a large number of cases will be found to adapt itself admirably to the work required to be done. The advantages claimed may be tabulated as follows: 1. A very large increase in working efficiency over any other known form of power transmission. 2. Considerable reduction in capital expenditure, when compared with other systems, a reduction which becomes more and more apparent as the distance for the power to be transmitted increases. 3. Increased facility in running the cables when compared with the laying of air or hydraulic mains. 4. Very small loss in the cables through resistance or leakage to earth when compared with the waste on a compressed air system. 5. Smallness in size of the machinery, thus proving itself to be of a portable nature and easily manipulated. 6. Absence of heat from the machinery underground. 7. Great simplicity in working. 8. Small cost of maintenance. 9. Finally, the ease and speed with which the whole plant can be erected and set to work. The principal objections raised against the employment of electric power are the following: 1. Danger arising from sparking at the motor brushes and main switch underground. 2. The idea that electrical machinery is of too delicate a nature for use in mines. 3. Risk of fire from breaking of the main cables by falls of stone, derailed tubs, or other causes. Having dealt with the three objections raised the author proceeded to consider the general question of electric power by electricity. When power is transmitted from one place to another by means of a fluid, such as steam, air, or water, through pipes, the difficulty of predetermining the exact loss of power from friction in these pipes is very great; in fact it varies so much under different circumstances that the author believed that exact determination may be said to be impossible. So, also, the loss of power in the motors driven by fluids is equally undeterminable with any degree of accuracy, on account of the variations in efficiency caused by slight alterations in load or speed, or by leakage through the valves or packings. These difficulties in calculation do not present themselves with electrical transmission of power. The loss of power in the cables depends solely on the electrical resistance, which is a practically constant quantity, and the current passing through the cables, which can be estimated with great accuracy. Nor is the loss of power in the motors more difficult to estimate: first, with a given motor the losses can be calculated with almost any degree of accuracy, from its known resistance and electrical or magnetic qualities; and, secondly, since the experimental determination of the efficiency of dynamos and motors is so readily carried out, a very great number of actual efficiency tests have been taken, from which the efficiency of a given size of machine of any particular type or construction can be easily foretold. The calculation, therefore, of the power wasted in transmitting power by means of electricity is extremely simple, and the efficiencies of a plant can be readily foretold, and the results to be obtained guaranteed with perfect confidence. The author thought that it might be of interest if he took two typical cases, and presented the results of the calculations in such a way that the members of the institute could compare them with those obtained in practice by any other methods. Having done this, he said that an inspection of the two tables which he gave would prove to the members with what ease and at what a comparatively small cost power can be transmitted to considerable distances, and he, therefore, desired to draw attention to one or two of the conclusions which are arrived at from this fact. First, where there are two or more collieries under the same management within a comparatively short distance of one another at which power is required, he would urge the desirability of establishing one central station where plant would be installed of sufficient power to serve the several collieries. The advantages of this plan are clear. (*a*) Inasmuch as all the machinery will not be working to its full capacity at each of the collieries simultaneously, the actual power at the one central station will be less than the sum of the powers which would have to be installed at each separate position, and in addition to this the plant would be cheaper, because the price of machinery does not vary directly as its output. (*b*) The cost of maintenance of a few large dynamos and engines will be less than that of a greater number of small ones. (*c*) Greater efficiency is obtained by running the machinery more nearly at its full load, the percentage variations of power required being smaller, when a large number of motors are taking power from the one plant. (*d*) The cost of attendance on the generating plant will be enormously reduced, the same number of men being able to attend the one central station as would attend to each of the separate plants. The great saving in all these directions had been fully proved by actual practice in the large central stations supplying light and power in London and other large towns.

COMPANIES' MEETINGS.

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY.

The fifth annual meeting of this Company was held on M[illegible] at the offices of Messrs. Leadbitter and Harvey, We[illegible] Newcastle-on-Tyne. Mr. John D. Milburn, chairm[illegible] presided.

The report and accounts were presented as fo[illegible] are happy to state that the prospects of [illegible]

[illegible]1	6	9
15,312	19	6
4,142	8	4
[illegible]	7	[illegible]

satisfactory. The installations connected to the mains during the year are equal to 4,000 16-c.p. lamps, bringing the total up to about 11,000, and 206,017 units of electrical energy have been supplied. The Company maintains amicable relations with its consumers, and trusts the consumption may ere long increase to a sufficient extent to enable the Directors to recommend a reduction in the price of current. The gross earnings during the year amount to £1,860. 15s., and after making provision for depreciation account and reserve fund, and writing off £200 from formation expenses, your Directors are able to recommend a dividend at the rate of 2½ per cent. for the half-year ending December 31, which, together with the interim dividend paid in July last, makes the dividend 5 per cent. for the year. Colonel W. M. Angus and Mr. John B. Simpson retire by rotation, but are eligible, and offer themselves for re-election. The auditors, Messrs. Strachan, Hill, and Co., also offer themselves for re-election.

Balance-sheet, 31st December, 1891.

Cr.	£	s.	d.	£	s.	d.
Capital—5,000 shares at £10 each..	50,000	0	0			
2,113 shares, £8 called up	16,904	0	0			
427 ,, £4 ,, ...	1,708	0	0			
	18,612	0	0			
Add calls paid in advance	1,316	0	0			
	19,928	0	0			
Less calls unpaid	132	0	0			
				19,796	0	0
Creditors.....................................	2,622	0	3			
Loans and interest	5,257	11	1			
Directors' fees, unpaid.................	105	0	0			
Bankers	671	2	3			
				8,655	13	7
Reserve fund				300	0	0
Profit and loss account, balance from last year	53	14	10			
Profit for year ending 31st Dec., 1891......	805	3	4			
	858	18	2			
Less interim dividend......	385	18	8			
				472	19	6
				£29,224	13	1
Dr.	£	s.	d.	£	s.	d.
Buildings and plant, pipes and cables (including cost of laying), meters, transformers, electrical instruments, etc., as per last balance-sheet..	17,036	8	11			
Expended since	8,874	8	5			
	25,910	17	4			
Less depreciation written off......	400	0	0			
				25,510	17	4
Office furniture				136	14	5
Stock of stores, etc.				93	0	4
Formation expenses, as per last balance-sheet.....	1,275	0	11			
Expended since	286	3	6			
	1,561	4	5			
Less amount written off	200	0	0			
				1,361	4	5
Debtors (less reserve for discounts, £200)				2,022	16	7
Hodgkin and Co., deposit				100	0	0
				£29,224	13	1

Profit and Loss Account for Year ending Dec. 31, 1891.

Dr.	£	s.	d.
Wages, salaries, rent, rates, taxes, and Directors' fees	1,323	6	6
Stationery and office expenses	106	5	6
Stores, fuel, water, etc.	1,413	9	5
Repairs and renewals	93	2	1
Balance	1,860	15	0
	£4,796	18	6
	£	s.	d.
Interest	255	11	8
Proportion of formation expenses written off	200	0	0
Depreciation written off	400	0	0
Transfer to reserve fund	200	0	0
Balance carried to balance-sheet	805	3	4
	£1,860	15	0
Cr.	£	s.	d.
Electric energy supplied, less discounts	4,557	14	1
Meter and transformer rent	239	4	5
	£4,796	18	6
	£	s.	d.
voltag. very smau field, and con. distributed, with..............	1,860	15	0
	£1,860	15	0

* Paper read befo.

February 11, 1892.

The **Chairman** said: In moving the adoption of the Directors' report, I ask permission to say a few words concerning the position and progress of our Company. I have to congratulate the Company upon the steady progress which has been made since its commencement. It is true we are as yet but a Liliputian enterprise, as compared with the growth of the gas company, but we have risen above the ground, and have ample reason to believe that we shall prosper. Our receipts during the financial year ending 31st December last have amounted to £4,796. 18s. 6d., as against nearly £220,000 of receipts by the gas company. We have no war with the gas company. The first time I had the honour of addressing you, I, on behalf of your Directors, intimated that the Newcastle and District Electric Lighting Company did not intend to enter into any insane competition with gas. We wished to supply an artistic, healthy, and exhilarating light at a higher price than gas. We have hitherto steadily pursued this policy with a fair share of prosperity for ourselves, and with the result that instead of doing harm to the gas company, its business has actually increased, and it is even now seeking a large amount of fresh capital to allow of extensions. We have, therefore, actually exhilarated the gas company, for the lighting of the city, whether by gas or by electricity, was never before so efficiently and so well done as at present. There is yet long life in the gas company, and when artificial lighting shall no longer be its strong point, it will have many other sources of revenue. In electricity, however, we represent the leading energy of this age, and your Directors will not be content until our Company grows and expands, until it is doing a fair share of the lighting of this city. Not only should we occupy ourselves with the production of energy for lighting purposes, but we should cultivate its use for motive power. I do not think we shall have many years to wait before tramways are principally worked by electricity. I am convinced that, as soon as we shall be able to show the directors of our local tramways any advantage in the use of electricity — especially on such horse-killing places as Westgate-hill — they will not be slow to adopt it. Electric motors will also be found useful for the propulsion of machinery in its manifold uses, and I think something more might be done by us to encourage the adoption of electrical motors. The use of our plant, or a large proportion thereof, during the daytime would considerably reduce our cost of production, and render remunerative to the Company the day hours as well as the night hours, upon which we have chiefly to depend for our revenue. Your Directors are fully alive to the interests of the public, and so soon as the business of the Company shall have attained sufficient volume, and the cost of production be reduced, they will recommend a reduction in price, and so bring the use of electricity into still greater popularity. No one who has once used the electric light has any inclination to go back to gas lighting. It would be more difficult to pervert a good Mahomedan than to wean back again a user of the electric light to gas, notwithstanding the higher price. Its advantages, comfort, healthiness, and cleanliness, are fully recognised and appreciated. If to these merits, however, comparative cheapness can be added, the two electric lighting companies of the city would very speedily open up "fresh woods and pastures new." That there is a great future before us, your Directors would fain hope. Coming to the results of the recent year's work, the shareholders may be interested to know that during the past year lamps equal to about 4,000 16-c.p. lights were connected to the Company's mains, and during the same time, 15,610 yards of cable have been laid, and 2,430 yards of main and branch piping. The 6in. main pipe which at the commencement of the Company's operations was laid in Fourth Banks, is now filled up with cable, and in view of the demands which are being being received for supply of current, it has been found necessary to commence laying another 6in. main.

Mr. J. R. Holliday seconded the adoption of the report.

The report was adopted, and the dividend declared.

The retiring Directors and the Auditors were re-elected.

A vote of thanks to the Chairman terminated the meeting.

COMPANIES' REPORTS.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY.

Directors: S. Wm. Silver, Esq., chairman; Neil Bannatyne, Esq.; Abraham Scott, Esq.; Matthew Gray, Esq., managing director; Robert Henderson, Esq.; the Hon. Henry Marsham; A. Weston Jarvis, Esq., M.P.

Report of the Directors for the year ending December 31, 1891, to be presented at the twenty-eighth ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, on Tuesday, February 23, at 12 noon.

The annexed accounts show the net profit for the past year to be £79,102. 8s. Adding £39,970. 17s. 10d. brought forward, and deducting £20,800 interim dividend paid in July, there remains a disposable balance of £98,273. 5s. 10d. The Directors have added £25,000 of this balance to the reserve fund (raising it to £325,000), and recommend the distribution of a dividend of 10s. and a bonus of 5s. per share, free of income tax, amounting to £31,200, making, with the interim dividend, a total payment for the year of 12½ per cent., and leaving £42,073. 5s. 10d. to be carried forward. The increase in the sales of the Company's general manufactures continues. The cable department has been fairly well employed. More than 1,600 miles of cable have now been manufactured for the South American Cable Company; and it is expected that the

whole length contracted for will be made and laid by Midsummer. The efficiency of the works and machinery has been fully maintained. Mr. Scott and Mr. Jarvis, the directors retiring by rotation, offer themselves for re-election. Mr. Weise is re-eligible as auditor.

Dr. Balance-sheet, 31st December, 1891.	£	s	d.
Amount of authorised share capital ...	812,000	0	0
Share capital—amount subscribed and paid on authorised issue of 41,600 shares of £10 each...	416,000	0	0
Mortgage debentures	200,000	0	0
Reserve fund	325,000	0	0
Steamers' maintenance fund	10,000	0	0
Debts and loans owing by the Company	83,329	13	8
Bills payable	16,608	17	0
Unclaimed dividends	7	0	0
Proposed dividend, 5 per cent., and bonus of 2½ per cent.	31,200	0	0
Amount carried forward to 1892, as below	42,073	5	10
	£1,124,218	16	6

Cr.	£	s.	d.
Freehold and leasehold premises (Silvertown, Persan, London, and Liverpool), machinery, and steamships	483,546	2	11
Debts owing to the Company	82,487	0	10
Cash with bankers and in hand	22,477	8	9
Bills receivable	4,432	5	4
Stock-in-trade, including cable and expenditure on account of contracts	347,857	14	7
Debentures and shares in other companies	25,290	10	0
Cash, stock, etc., at Persan and other agencies	158,127	14	1
	£1,124,218	16	6

Profit and Loss Account, Year ending Dec. 31, 1891.

Dr.	£	s.	d.
Salaries, interest, rent, rates and taxes, repairs, and general expenses	64,008	7	2
Bad debts	902	3	2
Income tax	1,326	12	0
Depreciation written off buildings and machinery...	23,235	7	10
Directors' remuneration (minimum)	2,000	0	0
Balance: Profit for the year, carried down	82,102	8	0
	£173,574	18	2

Addition to reserve fund				25,000	0	0
Interim dividend of 5 per cent., paid in July	£20,800	0	0			
Proposed dividend of 5 per cent.	20,800	0	0			
Proposed bonus of 2½ per cent.	10,400	0	0			
				52,000	0	0
Balance to be carried forward to 1892				42,073	5	10
				£119,073	5	10

Cr.				£	s.	d.
Gross profit, including interest on securities, and after charging commission and depreciation of steamships				173,574	18	2
				£173,574	18	2
Balance brought down	£82,102	8	0			
Less additional remuneration due to Directors after payment of 10 per cent. to shareholders	3,000	0	0			
				79,102	8	0
Amount brought forward from 1890				39,970	17	10
				£119,073	5	10

WESTMINSTER ELECTRIC SUPPLY CORPORATION.

Directors: The Right Hon. Lord Suffield, K.C.B., Edmund Boulnois, Esq., M.P., W. Hayes Fisher, Esq., M.P., Sir Douglas Galton, K.C.B., F.R.S., M.Inst.E.E., J. Browne Martin, Esq., James Heslop Powell, Esq., Roger W. Wallace, Esq. General manager: Captain Edmund I. Bax. Engineer-in-charge: Prof. Alex. B. W. Kennedy, F.R.S., M.Inst.C.E. Secretary: Frank Iago, Esq.

Report of the Directors to be presented to the shareholders at the ordinary general meeting to be held at the Westminster Palace Hotel, S.W., on Wednesday, the 24th inst., at 11 a.m.

In submitting their report and accounts for the year 1891 the Board of Directors are pleased to state that the business of the Corporation is making satisfactory progress, for although two of the stations were not in work until the end of March, and one is still in the builder's hands, the accounts of the past year show a considerable profit upon the working, after making provision for bad and doubtful debts, allowing a fair amount for depreciation, and writing off a proportion of the preliminary expenses and suspense account. In their report last year, the Board stated that current was being supplied to the equivalent of about 12,000 lamps of 8 c.p. At the present time current is being supplied to 67,500 lamps of 8 c.p., while applications are signed for a further 5,083 lamps of 8 c.p. The application to Parliament for permission to supply the northern district of Westminster was successful, the Royal assent to the Bill having been given on July 3, 1891. Mains have now been laid in all the scheduled streets throughout the area of supply, as also in every other street where the expenditure has been justified by the demand for current, both in the original and additional order. The total length of roadway along which mains have been laid up to the present date is about 31 miles. This includes a total of about 123 miles of ways, along which 89 miles of copper have been drawn. Your Directors have every reason to believe that the Corporation's supply, which has so successfully been given to the Houses of Parliament, will be extended to other Government offices at no very distant date. Two of the stations of the Corporation which had not been finished at the date of the last general meeting (the Mayfair station in Davies-street and the Belgravia station in Eccleston-place) commenced to supply current in March last, and, together with the Westminster station in Millbank-street, have since been constantly at work. The reports from consumers and others as to the quality of the light supplied have been very gratifying, and the increase in the number of applications for current received may no doubt be ascribed to this fact. As shown in the accompanying accounts the net revenue of the Corporation for the past year is £3,160. 4s. 3d., and this sum the Board consider should be carried forward. The balance of the authorised share capital—viz., £85,235 in 17,047 shares of £5 each—was, in accordance with the resolution of the shareholders at the general meeting in February last, issued at par, and was duly subscribed for; many of the original shareholders increased their holdings, and a number of the consumers on the Corporation's circuits invested in the shares. The whole of the authorised capital has now been subscribed and paid up in full, and it is very satisfactory to the Board to be able to state that there is not a single unpaid call. The Directors have not made any public issue of the debenture capital, for which powers are given in the articles of association, but have allotted £29,400 in 5 per cent. mortgage debentures to applicants, many of whom had applied for ordinary shares of the Corporation. The auditors, Messrs. Cooper Brothers and Co., retire, and, being eligible, offer themselves for re-election.

Dr. General Balance-sheet, Dec. 31, 1891.				£	s.	d.
Capital account as per account No. 3				329,400	0	0
Sundry creditors				15,322	3	0
Depreciation account, No. 6				1,000	0	0
Sinking fund on buildings and leases, No. 7				400	0	0
Net revenue account, No. 5				3,159	14	3
				£349,281	17	[illegible]
Cr.				£	s.	d.
Capital account, as per account No. 3				297,640	17	9
Stores on hand				99	4	4
Sundry debtors for current supplied	£9,773	19	10			
Other debtors	851	5	8			
				10,625	5	6
Deposits with vestries, etc.				184	14	10
Cash on loan against securities				30,000	0	0
Cash at bankers				1,350	17	3
Preliminary expenses and suspense account (being expenditure applicable to future business	£10,380	17	7			
Less amount written off for year 1891	1,000	0	0			
				9,380	17	7
				£349,281	17	3

Revenue Account for Year ending Dec. 31, 1891.

Dr.	£	s.	d.	£	s.	d.
A.—To Generation and Distribution of Electricity.						
Coals, carriage, and unloading, etc.	3,581	10	0			
Oil, waste, water and engine-room stores	984	19	9			
Proportion of salaries of engineers and officers	1,035	14	9			
Wages and gratuities at generating stations	2,763	6	6			
Repairs and maintenance: Buildings, £49. 14s. 3d.; plant, £298. 2s. 8d..	347	16	11			
				8,71	7	11
B.—To Rents, Rates, and Taxes.						
Rents payable	1,230	3	4			
Rates and taxes	337	7	11			
				1,567	11	
C.—To Management Expenses.						
Directors' remuneration	800	0	0			
Salaries of manager, chief engineer, secretary, clerks etc.	1,962	16	8			
Stationery and printing	249	11	10			
General establishment charges	164	12	1			
Auditors of Company and accountants' charges	68	19	10			
				3,246	0	5
D.—To Law and Parliamentary Expenses.						
Law expenses				294	13	2
E.—To Depreciation.						
Sinking fund on building and leases	400	0	0			
Depreciation on plant and machinery, etc.	1,000	0	0			
				1,400	0	0
F.—To Special Charges.						
Insurance				91	6	9
Total expenditure				15,312	19	6
Balance to net revenue account No. 5				4,142	8	4
				£19,455	7	[illegible]

Cr.	£ s. d.	£ s. d.
Sale of current by meter, etc.	18,131 5 0	
Sale under contracts	981 11 8	
		19,112 16 8
Rental of meters on consumers' premises		288 18 8
Transfer fees..		53 12 6
		£19,455 7 10

BUSINESS NOTES.

West India and Panama Telegraph Company.—The receipts for the half-month ended Feb 15 were £2,655, against £3,236.

Warrants for Interest at the rate of 6 per cent. per annum on the preference shares of the Western Counties and South Wales Telephone Company, Limited, for the half-year ended December 31st last, have been posted.

City and South London Railway.—The receipts for the week ending 14th February were £881, against £728 for the corresponding period of last year, showing an increase of £153. As compared with the week ending February 7th, last week's receipts show an increase of £57.

Birmingham Electric Supply Company. —We notice that 5,625 shares of £5 each in this Company, being the balance unissued, are now being offered in Birmingham at par. Five shillings is to be paid on application and 15s. on allotment. Any subsequent calls are not to be for more than £1 per share at three months' notice, and at intervals of not less than three months. Existing shareholders will have priority of allotment.

PROVISIONAL PATENTS, 1892.

February 8.

2365. **Improvements in electrical communicating apparatus for mining and other works.** Alexander Ferrie Mabon, 87, St. Vincent-street, Glasgow.

2393. **Improved method of and appliances for using electricity as a medicinal agent.** William Grigg, 11, Furnival-street, Holborn, London.

2396. **An improved microphone or transmitter.** John Henry Kindle, 9, Warwick-court, Gray's Inn, London.

2397. **Electric fire alarm.** Ernest Dyer Wise, 69, Lever-street, Goswell-road, London.

2401. **Improvements in incandescent lamps.** Perrin Grant, Monument-chambers, King William-street, London.

2417. **Apparatus to gather and store electricity or energy from water, the earth, or from the atmosphere.** Richard Joseph Crowley, Queenstown, Cork, Ireland.

February 9.

2438. **Improvements in relays for submarine telegraphy.** Gaspare Sacco, 7, Martin's-lane, Cannon-street, London.

2448. **Improvements in and connected with the arrangement and operation of relays in telegraphic systems.** William Frederick Wentz, 70, Market-street, Manchester. (Complete specification.)

2486. **Improved composition of matter suitable for use in the manufacture of journal bearings packings, projectile rings, commutator brushes, and various other articles where surfaces come into frictional contact, and for conductors of electricity.** Philip Henry Holmes, 47, Lincoln's-inn-fields, London. (Complete specification.)

2488. **Electric lighting system.** Sylvanus Lander Trippe, 33, Chancery-lane, London. (Complete specification.)

2497. **Improvements in magneto-electric machines.** John Hunt, 55, Chancery-lane, London. (Complete specification.)

2540. **Improvements in the arrangements of conductors for electric traction.** John Edward Waller, 47, Lincoln's-inn-fields, London.

2541. **Apparatus for and method of recording the time during which telephones, phonographs, and other instruments or machines are in use or at work.** Bernhard Heinrich Carl Bogler, High Holborn, London. (Karl Strecker, Germany.)

2544. **Improvements in electrical motors.** Alfred Julius Boult, 323, High Holborn, London. (William Joseph Still, Canada.) (Complete specification.)

February 10.

2588. **Improvements in telephonic switching apparatus.** Ernest Frank Furtado and Charles Benjamin Oakley, 48, St. Paul's-road, Camden Town, London.

2618. **Improvements in electrometers.** Paul Bary, 28, Southampton-buildings, London.

2621. **An improved telephone combination.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London.

February 11.

2646. **Improvements in telephonic transmitters.** Luis Larranaga, 36, Chancery-lane, London.

2652. **Improved regulator for voltaic arc lamps.** Frédéric Klostermann, 3, Tokenhouse-buildings, London.

2653. **Improvements connected with electrically operated coin-freed apparatus.** Herbert Edwin Langley, 166, *Fleet-street, London.*

2690. **Improvements in electric arc lamps.** Henry Tipping, 55, Chancery-lane, London.

2722. **Improvements in electric switches.** Alfred Lyster Shepard, 45, Southampton-buildings, London.

2724. **Improvements in electro-therapeutical apparatus.** Armin Grimm, 45, Southampton-buildings, London. (Complete specification.)

2727 **Improvements in telephone receivers.** Oliver Imray, 28, Southampton-buildings, London. (Ferdinand Gross, Canada.)

2733. **Improvements in and relating to the driving and controlling of riveting, shearing, punching, and other machines by electricity.** Albert Piat, 46, Lincoln's-inn-fields, London.

February 12.

2743. **The application of electricity to a scientific puzzle.** Algernon Sidney Field, Aberdeen Lodge, Worple-road, Wimbledon.

2744. **Improvements in telephonic instruments.** Berthold Hoffman, 70, Market-street, Manchester. (Complete specification)

2748. **Electro-heliograph suitable for interastral communication.** Richard Joseph Crowley, Queenstown, co. Cork, Ireland.

2762. **Improvements in or relating to electrical signal apparatus for indicating the position of railway switches or points.** William Phillips Thompson, 6, Lord-street, Liverpool. (Paul Schwenke, Germany.) (Complete specification.)

2775. **Improvements in ozonising or electrifying atmospheric air or other gases.** Richard Arthur Prior Taunton, 11 Furnival-street, Holborn. London.

2784. **Improvements in or relating to sockets and switches for incandescent lamps.** John Clayton Mewburn, 55, Chancery-lane, London. (David H. Piffard, United States.)

2785. **Improvements in incandescent electric lamps.** John Clayton Mewburn, 55, Chancery-lane, London. (David H. Piffard, United States.

2791. **An improved time-registering device for electric currents.** Walter Cobb, jun., and William D. Wilder, 55, Chancery-lane, London.

February 13.

2831. **Improvements in apparatus for the driving of chronometric balances and pendulums for electricity meters.** Joseph Oulton, and Joseph Edmondson, Bank-chambers, Waterhouse-street, Halifax.

2849. **Improvements in and relating to electrical devices for operating railway points.** William Phillips Thompson, 6, Lord-street, Liverpool. (Emile Klatte, Germany.)

SPECIFICATIONS PUBLISHED.

1890.

20651. **Electrical transformers.** Mance. 6d.

1891.

1049 **Dynamo-electric machines.** De Ferranti. 8d.
1051. **Electrical transformers.** De Ferranti. 11d.
1051A. **Testing electrical transformers, etc.** De Ferranti. 8d.
4689. **Electric switches.** Challis. 8d.
4988 **Type-printing telegraphic instrument.** Thompson. 8d.
5131. **Applying electricity for therapeutic, etc., purposes.** Lawrence. 8d.
5341. **Electrical transformers.** Poleschko. 8d.
5406. **Telegraph pole attachments.** Jobson. 8d.
5485. **Telephonic communication.** Massin. 8d.
6232. **Microphones for telephonic circuits.** Gwosdeff and Bungé. 8d.
12824. **Electric lighting.** Zanni. 6d.
13705. **Coupling electric wires.** Shiels. 6d.
20367. **Electric wire couplings.** Shiels. 8d.
20933. **Electrically-propelled hose-carts.** Dewey. 8d.
21476. **Electric meters.** Waterhouse. 8d.
21963. **Electric railway systems.** Dewey. 8d.
22181. **Pads for electric cells.** Rogers 8d.
22473. **Electrical heating apparatus.** Drevs. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3½
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	22½
House-to-House	5	5
Metropolitan Electric Supply	—	8⅞
London Electric Supply	5	1¼
Swan United	3½	4¼
St. James'	—	8⅝
National Telephone	5	4¼
Electric Construction	10	6¼
Westminster Electric	—	6⅛
Liverpool Electric Supply	5	5
	3	2⅞

NOTES.

Warsaw is to have an electric light station.

Llandudno will shortly want a new gasholder. Why not a dynamo-room?

Mansfield.—The price for public gas lamps is nearly £4 a year in Mansfield.

Leeds.—The Board of Trade have approved of the extension of the Leeds electric lighting order until April 3rd, 1892.

Deputation from the City.—A section of the Commissioners of Sewers will visit the Crystal Palace Exhibition on Tuesday.

Lundy Island.—Another wreck has been totally lost at Lundy, to a large extent from want of telegraphic communication to the mainland.

Dundee is to have a new post office. All new large post offices are now lighted electrically, and Dundee will, we may suppose, be no exception to this rule.

Liverpool Tramways.—The Liverpool Tramway Company is extending a mile of line, at £2,200 a mile for the permanent way, single line, with passing-places.

The Manchester Co-operative Stores in Balloon-street are lighted by incandescent lamps, the current for which is generated by a Parsons steam turbine plant.

Coventry.—Mr. West will bring in a motion at the next meeting of the Coventry Town Council that a deputation be appointed to visit the Crystal Palace Exhibition.

Electric Heaters.—The use of electric heaters in the tramcars in those cases where they are used, are found to make no perceptible difference in the current consumption.

Edinburgh Tramways. — The Portobello Local Authority have determined to petition against the Edinburgh Tramway Bill, which is being promoted by the tramway company.

Sir William Thomson's Title.—In Tuesday's *Gazette* the titles of the new peers are given. That of Sir William Thomson is "Baron Kelvin, of Largs, in the county of Ayr."

Tesla's Experiments.—Mr. J. E. H. Gordon will contribute an article on Mr. Tesla's experiments to the March number of the *Nineteenth Century*.

Registered Electrical Contractors.—"Lux," in the *Manchester Guardian*, suggests that the Council should only allow competent and registered electrical contractors to fit up installations for the city electric system.

Killed by Lightning.—An unusual occurrence happened at Dartmoor last Saturday, when a healthy lad of 14, named William French, was found dead in bed, having been struck by lightning while asleep. This is almost a unique accident.

Barnet.—The Barnet Local Board are complaining of the bad state of the gas lighting, and have instructed the clerk to write to the gas company. The progressive section of the Board should send a deputation to see the lighting of Fareham.

Government and Coast Telegraphs.—Mr. Penrose Fitzgerald has given notice that on March 16 he should move a resolution, on going into Committee of Supply, with reference to telegraphic communication between light-houses and lifeboat stations.

King's College.—The Siemens Laboratory at King's College, London, was formally opened by Sir W. Thomson on Friday last. This laboratory has been equipped and presented to the college by Lady Siemens, in memory of the late Sir William Siemens.

New Journal.—We have received *Sciences et Commerce*, a new French journal devoted to applications of science, in which electricity bears a large part. The London agent is Geo. Street and Co.; the price 60c.; fortnightly. It makes a handsome appearance.

Office Manual.—Young engineers going into business will find the "Universal Office Manual" (Oxborrow and Co., 17, Victoria-street, S.W., 5s.) of use to them for guiding them in the necessary details of commerce, book-keeping, and finance, into which it goes very fully.

Cork Tramways.—The Board of Works held a public enquiry in Cork with reference to the proposed tramways on Monday. The cars are to carry 24 passengers, and will weigh 28cwt. each. The city engineer objected to the use of overhead wires if electric traction were to be used.

Acid Fumes.—The discomfort from the acid fumes from the batteries in the Birmingham electric cars is causing much discussion. Coughing is said to be frequent from the acid spray emitted. There should be no difficulty in having sufficient air-holes under the seats to prevent discomfort from this cause.

Portsmouth.—The estimated cost of the plant for Portsmouth on the high-tension scheme recommended by Prof. Garnett is £38,285, while the annual receipts from private and public lighting are expected to reach £10,800. The expenditure, including interest on £40,000, at 3½ per cent., is estimated at £7,572.

Purchase of the Telephone System. — Dr. Cameron has given notice to call attention, on the Civil Service Estimates, to the relations between the Postal Telegraph Department and the telephone system. He will bring forward a motion in favour of the acquirement of the telephone system by the Post Office.

Electric Mains in Paris.—One of the Paris electric light companies is to spend 1,300,000f. in altering its underground mains and laying mains in two new streets. The *Bulletin International* remarks that it is said in Paris the cost of laying a metre of underground mains comes to 90f., and after altering and repair to 150f.

Book Received. — We have received a copy of "Modern Practice of the Electric Telegraph—a Technical Hand-book for Electricians, Managers, and Operators," with 185 illustrations, by Franklin Leonard Pope, fourteenth edition, rewritten and enlarged. (New York: Van Nostrand; and London: Sampson Low and Co.)

City Meat Market.—The Streets Committee of the Commissioners of Sewers recommend that the Central Markets Committee be informed that there are contracts for lighting the public streets of the City, and owners can arrange for private lighting, but there is nothing to prevent the meat markets producing their own light if they so desire.

Switch Catalogue.—We are in receipt of the catalogue of Mr. A. P. Lundberg, of Bradbury-street, Kingsland, whose switches are well known, being amongst those earliest in the field for small practical switches. Some new kinds of switches and wall sockets are shown, besides good types of main switches and the original "Pioneer" switch.

Saving Power.—The current in driving electric cars is often far more greatly increased by dust between rails and wheels than most persons would be inclined to suspect. The best way to reduce this is by having periodical washing by salt water, which has been found in practice by American

roads to reduce the consumption 30 per cent.—from 900 to 600 amperes.

St. Helens.—The Local Government Board have written to the St. Helens town clerk (Mr. W. J. Jeeves) sanctioning the borrowing of £1,500 for electric lighting of the Town Hall. For the accommodation of the dynamos the Water Committee's storage is being removed from the Town Hall yard to a building specially erected for their accommodation.

Flying Machine.—We stated last week that the flying machine, constructed upon the model of the flying fox, was made by Messrs. Shaw and Sons, of Coventry. Mr. Albion T. Snell, engineer to the General Electric Traction Company, writes to inform us that the machine and motor have been made by that company to designs by Major Moore; the wings only have been made by Messrs. Shaw.

Electric Fire Engine.—The Kummer electric fire engine, made by Messrs. Kummer, of Dresden, uses 50 amperes at 100 volts, or 75 amperes at 65 volts, being 500 watts. The pump throws 500 litres of water per second, and, with a nozzle of 18 mm. diameter, gives a height of throw of 35 to 40 metres. It weighs 2¼ tons, and costs only about half that of an ordinary steam fire engine.

Electric Bells.—The new (ninth) edition of the General Electric Company's catalogue of electric bells has just been issued. Besides bells, pushes, commutators, and all necessary fittings of many and varied kinds for electric bells, it gives illustrations of some neat and cheap sets of students' experimental sets for studying frictional and current electricity, which should prove of use to schools.

Resistance of Cobalt.—Prof. C. G. Nott, in a paper to the *Proceedings* of the Royal Society of Edinburgh, comes to the conclusion experimentally that between the temperatures of 400deg. C. and 700deg. C., the resistance of a cobalt strip increases on an average at a rate nearly twice as great as the average rate of increase between 0deg. and 300deg. C. He also investigates the thermo-electric position of cobalt.

Electrocution at Abattoirs.—The abattoir (public slaughter-house) at Aberdeen is about to be lighted by electricity. In the event of the use in this direction of an alternating-current dynamo, a trial will be made of its capabilities for slaughtering cattle. It is anticipated that this application may become general if experience should prove that it has no detrimental effect upon the quality of the meat.

Chicago Congress.—The work of organising the congress in Division E, Electrical Engineering, during the Chicago Exhibition, is assigned to the American Institute of Electrical Engineers. Suggestions are invited. Papers will be admitted from engineers all over the world and in any language (to be translated). Copies or abstracts will be printed. The work of organising is to be at once undertaken.

Blackpool.—The Blackpool Corporation are going in for an extended scheme of electric lighting. This will include the extension of the present lights along the promenade to the extreme end of South Shore, and as far as The Glynn Inn, North Shore. It is also proposed to illuminate several of the principal thoroughfares with the electric light, and likewise supply shops and places of business requiring it.

Croydon.—The new municipal buildings at Croydon are to be wired for electric light, so that if no private company undertook the work the Corporation might eventually supply themselves with electric light. The Mayor considered the Council had nothing to lose by a little delay. It is suggested that an electric installation might be established at the Croydon pumping station for lighting the Town Hall.

Society of Arts.—Prof. William Robinson, of Nottingham, is about to deliver a course of four Cantor lectures on the "Uses of Petroleum in Prime Movers," before the Society of Arts, on successive Monday evenings, the first lecture being on Monday next, 29th inst. After dealing with the subject generally, the lecturer will treat of petroleum oil engines, oil gas, and gaseous fuel for steam boilers.

Electric Railways Deferred.—At a meeting of the Illinois central board of directors, in Chicago, the project of using electricity as a motive power for trains was abandoned. The special committee of directors which has been investigating the matter reported that, so far as they could ascertain, the development of electricity as a motive power has not yet progressed far enough to warrant the company in attempting to use it in place of steam.

Telephone in the Army.—At the Royal United Service Institution last Friday Major Beresford, R.E., lectured on "The Telephone at Home and in the Field." The great requirements were an improved telephone and a wider knowledge of shorthand. Telephones could be employed for coast defence, artillery, submarine mining, rifle and artillery ranges, communication in the field, intercommunication in camp, and for outpost duty.

Electric Float.—The *Daily Graphic* on Monday describes and illustrates an invention by Mr. J. Hibberd, of Cardiff, for connecting the shore with a ship in case of shipwreck. It consists of a pointed float of sheet iron, with electric motor and propeller ballasted with sand, which is discharged when the float strikes the ship, and the float rises to the surface, allowing connection by cables to be made. An incandescent lamp is used as guide.

Liverpool.—At the meeting of the Liverpool Watch Committee on Monday, the clauses setting forth the terms agreed upon by the committee and the Liverpool Electric Supply Company last week were approved of. The Corporation will have the power, if the agreement be endorsed by the Council, to purchase the undertaking of the company as a going concern at any time after the 30th of June, 1898, upon giving 12 months' notice of their intention.

Bury.—An expert in engineering and electric lighting has visited Bury (Lancashire) and made an inspection of the various weirs and waterfalls on the two local rivers, the Irwell and Roch, with the view of advising upon their capabilities for supplying power to drive the dynamos in order to furnish the town with electricity for lighting purposes. It is understood that owing to the very irregular flow of water in the two rivers named that such a scheme will not be recommended.

Telegraph to Gilgit.—Mr. Olpherts, the officer of the Telegraph Department who has been examining the route for the extension of the wire through to Gilgit, has returned to Srinagar. He has seen the passes at their worst and can now judge of the chances of the telegraph being kept up even in the severest snowstorms. He will probably, says the *Indian Engineer*, be summoned to Calcutta to consult with Mr. Brooke, director-general of telegraphs, regarding the construction of the line next summer.

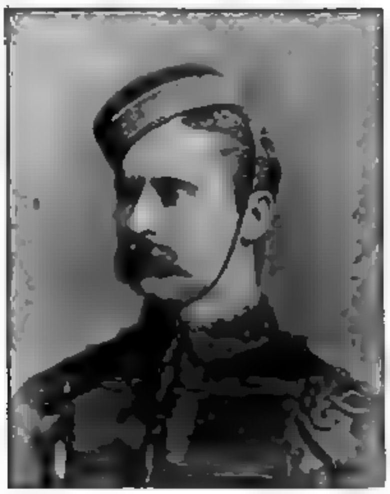
Spurgeon's Orphanage.—An action has been brought by the authorities of Spurgeon's Stockwell Orphanage against the City and South London Electric Railway Company, to restrain the company from causing vibration. The defendants pleaded statutory right. Mr. Justice Kekewich on Tuesday said the defendants were right in law, but as, according to the report of the engineer, they had not at first done all that was possible to mitigate the nuisance,

A. M. STUART.

ROBERT HAMMOND.

RAYNSFORD JACKSON.

COL. DU PLAT TAYLOR.



CAPT. HOLDEN.

they must pay the costs of the action up to the end of 1891, and £50 damages.

Fire at Messrs. Hodges and Todd.—Referring to the fire which occurred last Thursday in Verulam-street, which completely destroyed the works of Messrs. Hodges and Todd, we are pleased to learn the fire did not originate on their premises, as reported by many of the daily papers, but commenced on adjoining premises. They have secured new premises at 19, Kirby-street, Hatton-garden, and the work of fitting up is being rapidly pushed forward, and in a few days they hope to be able to execute all their orders.

Mutual Telephone Company, Limited. — The February list of subscribers to this company's Manchester exchange contains over 1,000 names. This is the result of exactly 12 months' working, the exchange having been opened on February 28, 1891, with 68 subscribers. Counting the orders on hand still to be executed, irrespective of those daily received, the Mutual Company's exchange has already attained greater proportions than that of the National Company in the same town. The company has also 500 spare metallic circuits erected and a number of private lines.

Pamphlets Received.—We are pleased to acknowledge some very interesting electrical pamphlets and reprints forwarded to us by Prof. W. E. Ayrton, F.R.S., President I.E.E. These comprise papers on "Quadrant Electrometers," from the *Proceedings* of the Royal Society, by Prof. Ayrton, Prof. Perry, and Dr. W. E Sumpner; on "The Construction of Non-Inductive Resistances," from the *Phil. Mag.*, by Prof. Ayrton and Mr. T. Mather; on "Alternate Current and Potential Difference Analogies in the Methods of Measuring Power," from the *Phil. Mag.*, by Prof. Ayrton and Dr. Sumpner.

Telephone Bills.—The town clerk of the Gravesend Town Council, at the special meeting last week, reported objectionable features in these Bills, in which the National Telephone Company, Limited, more especially sought very unusual powers, both as regards public and private property, for the whole of England, and this without offering to bind themselves to supply communication or to limit its price or the rate of dividends they might divide. The committee recommend the Council to petition against both Bills, on the understanding that the opposition be undertaken through the Municipal Corporations Association, at a cost not exceeding £20.

Islington Electric Railway.—The parliamentary estimates of the cost of extending the City and South London Railway to Islington have been prepared by Mr. J. H. Greathead, the engineer to the company. The length of this extension is given in these estimates as two miles five furlongs three chains, and the total cost is set down at £706,633. Of this sum, £330,540 will, it is estimated, be spent in tunnelling, £211,000 upon the acquisition of land and buildings, £81,600 upon stations, and £13,500 for the subway for foot passengers to and from Fish-street-hill. The laying of the permanent way will absorb £15,844, of which £2,500 will be for sidings, whilst for contingencies a sum amounting to £54,149 is allowed.

Railway Station Indicator.—Considerable discussion has been aroused in the daily papers with reference to the statement by the President of the Board of Trade that he was not aware of any mechanism by which the indication of the names of stations could be given in the carriages themselves. One suggestion is that no mechanism is necessary, but that the porters should slip at each stopping, place cards with the name of the station into slots at the windows. This is simple but clumsy, and could hardly be found to work in practice. We may mention that in the Crystal Palace Exhibition, South Gallery, is an electric railway station indicator, to be worked from the guard's van, shown by Messrs. Thatcher and Devereux, 15, Chivalry-road, Battersea.

Shiplighting.—A preliminary trial of the dynamos and electrical fittings of the cruiser "Edgar" was made at Keyham on Tuesday, but was not completed. The "Edgar" has been supplied with three dynamo-engines of the Siemens type, one of which is to be used under ordinary circumstances, whilst the other two—which are protected from shells by the ship's engines—are intended for use in action. Each of the three engines is capable of developing 400 amperes at 80 volts, and is intended to light the ship throughout, besides supplying the necessary force for working four search-lights of 2,500 c.p. The "Edgar" is lighted internally by 400 incandescent lights of 16 c.p. Sunbeam and yardarm lights will be supplied for special purposes such as coaling. The bunkers and magazines are also lighted by electricity.

Arc v. Incandescent.—The proposal having been made to use 150-c.p. incandescent lamps for street lighting at Portsmouth, Mr. Jas. Blake, managing director of the Fareham Company, writes to the Portsmouth paper to point out that while two 150-c.p. lamps would take nearly 4 h.p., a 1,200-c.p. arc can be produced for ½ h.p., or, allowing 50 per cent. for globe absorption, say, 600 c.p., giving a difference in favour of arcs of eight to one. In maintenance, at three renewals a year, the eight incandescents would cost 60s., while his experience with arc lamps shows that 40s. would not be exceeded for consumption of carbons. He asks the Portsmouth Town Council to send a deputation to visit their small neighbour, when he promises to show them "a mile and a half of the best-lighted streets in this country."

Goole.—At the monthly meeting of the Goole Local Board, held last week, Mr. Hind said that he wished to move an amendment in respect of that portion of the minutes relating to laying of electric cables. He wished to move that permission be given to lay down electric cables, subject to the restrictions that an agreement be entered into between the promoters of the electric company and the Local Board, giving them the power, and that power should be given to the Board to at any time purchase the electric works from the applicants, at a price to be fixed by the valuers, in the usual way. The reason he moved this was that it would be necessary, in case the Local Board took the gas lighting over, they should also have the electric lighting. This was carried, with an addition that the permission be given subject to such by-laws and conditions as the Board may hereafter make.

Systems of Traction.—An American engineer is at present in England wanting English capitalists to take up his system of open conduit for electric traction. Meantime, Messrs. Siemens's system, as used at Budapest, is being taken up in America by a powerful syndicate, who are going to lay six miles at once. Messrs. Manville and Waller, of Victoria-street, have an excellent open-conduit system which they are willing to instal at once on orders being received. We hear nothing further awhile about Mr. Gordon's closed-conduit system. Possibly something practical may come of this. Mr. Lineff is hardly doing as much as was expected of him. Accumulator traction is being quietly organised for large strokes of business, and the Thomson-Houston Company has shown us the way in overhead work, and may be expected to develop other work vigorously. Mr. Holroyd Smith is reported busy on his experimental line, and other schemes are in the wind. Surely electric tramway work in England must shortly go ahead with all this stirring enterprise beneath the surface.

Boiling Magnets.—The influence of steam on magnets is the subject of an interesting note in the *Schweizerische Bauzeitung*, in which reference is made to the researches of Strouhal and Barus. These have shown that with long-continued heating in steam, magnets lose from 28 to 67 per cent. of their power. If, after this, the magnets are remagnetised and again exposed to the action of steam, only a very slight loss of magnetic power is found to take place. The experiments which have been made would seem to warrant the conclusion also, that after such treatment a magnet is less liable to deterioration from mechanical vibration as well as heat. In one of the experiments a short magnet was boiled in water for four hours. It was then magnetised and held in an atmosphere of steam for two hours more, after which its magnetic moment was measured. It was then subjected to 50 blows from a piece of wood, both transversely and longitudinally. Again measuring its magnetic moment showed a loss of $\frac{1}{900}$, and on repeating the hammering with the wooden bar the loss was $\frac{1}{400}$ of the original moment. In view of this, repeated steaming and magnetising is recommended as a good means of securing permanent magnetism in pieces of hard steel.

A New Use for the Microphone.—Prof. D. E. Hughes, F.R.S., writes to us from 69, Pall mall, S.W., yesterday: "Having been engaged for many years experimenting with my microphone for the detection of sounds too feeble for the unaided human ear, I am pleased to notice by the following paragraph in the *Daily Telegraph* of February 25 that it has been successfully applied in St. Petersburg to the saving of human life." The paragraph says: "Some particulars of a remarkable case of revival from apparent death have come to hand from St. Petersburg. A lady who had been suffering from a violent nervous attack sank into a state of syncope, and after a time ceased, as it seemed, to breathe. The doctor who was attending her certified that death had resulted from paralysis of the heart. For some reason which is not explained another medical man, Dr. Loukhmanow, saw the body, and having been informed that the lady had suffered from attacks of hysteria and catalepsy, thought it worth while to make a thorough examination. After trying various other means he applied the microphone to the region of the heart, and was enabled by this instrument to hear a faint beating, which proved that life was not extinct. Everything was done to resuscitate the patient, who, shortly afterwards, recovered consciousness."

H.M.S. "Ramillies."—The forthcoming launch of the new first-class twin-screw battleship H.M.S. "Ramillies" will take place at Clyde Bank on Tuesday, March 1st, at 1.30 p.m. Electricity has played a considerable part in building the ship, the temporary installation being under the charge of Mr. John Young. The ship's sides were bored by electrical drillers, made especially for the occasion by Messrs. McWhirter and Ferguson, Faraday Electrical Works, Govan, under the superintendence of Mr. A. A. Stewart, chief engineer, Clyde Bank Shipyard. The belt deck and other decks were also drilled by three other electrical drillers. The diameter of holes in the ship's side were 5½in., 8in. of teak being bored before penetrating the two steel plates, each 3¼in. thick. Electric light is, of course, used—at the large cutters six 400-c.p. Sunbeam lamps on deck, and six below in the stokeholes and engine-rooms. There are also 100 16-c.p. incandescent lamps, and another 200 are being fitted up for present lighting in magazines, shell, store, and ammunition rooms, passages, and other places throughout the ship. The current is now supplied from a Crompton dynamo, working at 110 volts, driven off shafting in connection with shipyard machinery, a main cable, $^{19}/_{14}$, being employed. After launching, the installation will be supplied by a Robey portable engine and boiler combined, and a Paterson and Cooper dynamo will be employed on deck for temporary lighting. The battleship is to be christened by her Grace the Duchess of Abercorn, and a large concourse of spectators and visitors is expected.

Church by Telephone.—Several instances have lately been recorded of the transmission of church services by telephone. One of the most successful of these seems to have been that carried out the other Sunday—from Christ Church, Birmingham, to Derby, 40 miles away. An "extra-parochial" congregation of 17 persons assembled to take part in the telephonic service arranged for them by Mr. Ollerenshaw, the district inspector of the National Telephone Company. At 10.30 a.m. they seated themselves before the table, on which lay a number of ordinary Bell receivers. The bell was tolling loud and clear, and was audible over the room. Then it ceased, and nothing was audible except the broken murmur of footsteps and the opening of books. A soft note was heard through the murmur, then bursting into the full power of the organ, and again subsiding. Next a voice, which soon recited the familiar "Dearly beloved brethren," every word being distinctly articulated. The responses, the psalms, and *Jubilate* were all so realistic as to render it difficult for the listeners to remember they were not in church. The Birmingham church is the only one in the Midlands yet fitted with telephone. The arrangements are somewhat complicated, and include transmitting microphones in the choir and belfry, and before the pulpit, lectern, and reading-desk. The churchwarden has a switchboard in his pew, and his duty is to keep the proper transmitter in circuit. Already "church" is supplied regularly to about a hundred people in Birmingham and district, some of whom have not been able to attend a service for years previous to the introduction of a telephonic service.

Glasgow Tramways.—A deputation representing the Glasgow Corporation last week went for a week's tour for the purpose of enquiring into the various methods of tramway traction in use throughout the country. The party was headed by Bailie Paton, accompanied by Bailies Wallace and Stevenson, Councillors Bell and Thomson, Mr. Rankine, C.E., and Mr. Arnott, the city electrician. They commenced their enquiries at Chester, where they witnessed some experiments with low-pressure compressed-air cars by Messrs. Hughes and Lancaster. From Chester, on the Monday night, they proceeded to Birmingham, where on the following day they had an opportunity of inspecting the electric and cable tramway system of that city. The deputation afterwards journeyed to London, where they were shown the electric storage cars at Barking-road, and afterwards the conversion from horse to cable traction of the South London tramways at Brixton. Setting out again for the North, Bailie Paton and his associates arrived in Leeds on Thursday night, and spent the day in that town. They were received by Alderman Firth, the chairman of the Corporation Highways Committee, and Mr. Prince, superintendent of the highways department. In the morning they inspected the electric car section on which Leeds people are conveyed from Sheepscar to Roundhay Park, as well as the site of a proposed extension of that branch of the tramway system from Beckett-street to York-street. The deputation were conducted over this recently-made experiment with electric car by Mr. Davenport, the managing director of the Thomson-Houston Company, and by Mr. Graff-Baker, the lessee of the Roundhay Park line. The party expressed their gratification and interest in all they had seen.

City Electric Railway.—At the meeting of the Commissioners of Sewers on the 21st, Mr. Clarke presented the report of the Local Government and Taxation Committee, asking the Court to order the presentation of petitions against the following Bills, with authority to engage the services of an engineer: Central London Railway, City and South London Railway (Islington extension), Great Northern and City Railway, Royal Exchange and Waterloo Railway, and Waterloo and City Railway. Mr. Clarke said the committee reported that they considered the time had arrived when the Government should consider the whole question of these electric railway enterprises, because their number seriously threatened many portions of the City of London. There was a proposal to interfere with several important public ways in the City; while there was another proposition to construct a tunnel near London Bridge, which was giving the Bridge Committee much anxiety. There was a proposition also by one of these railway companies to take up underground the vacant space between the Mansion House and the Royal Exchange. But by agreeing to the report of the committee the Corporation would possess a *locus standi* before a committee of the House of Commons when these questions were being considered. It was considered very necessary that Colonel Haywood should be consulted, together with perhaps another eminent engineer like Mr. J. Wolfe Barry, because the committee felt that Colonel Haywood knew more about the wants of the City streets than any other man in London. Mr. Deputy Bedford agreed that this matter was of immense importance to the City of London, and would have to be approached with the utmost care and watchfulness. Mr. Deputy Haywood asked if the Waterloo and Exchange Railway Bill had not been withdrawn. The Remembrancer replied in the negative. The report of the committee was then unanimously adopted.

Coast Communication and Defence.—The following information and statistics have been sent us by Mr. J. Lawrence-Hamilton, M.R.C.S., late honorary president Fishermen's Federation, of 30, Sussex-square, Brighton: The United Kingdom has an indented coast line probably exceeding 10,000 miles. Telegraph overhead wires and posts at, say, £40 a mile would cost upwards of £400,000. To supplement its 681 coastguard stations, which in case of war are to be increased by 78 extra stations, the United Kingdom requires upwards of 700 new signal stations, which at about an average rate of £1,200 each might cost, say, £840,000. Besides shore lighthouses, the United Kingdom possesses probably upwards of 100 rock lighthouses without submarine cables. The cable from Tory Island rock lighthouse to the shore cost about £6,000, which sum may be often exceeded for similar purposes. Cables connecting lightships to the shore are easily snapped by the to and fro swinging of the vessels, especially during storms, gales, etc. Excluding the connection of lightships to the shore, a complete coast communication would probably involve an initial expenditure exceeding £5,000,000, and over £350,000 a year for maintenance. The 1891-1892 surplus postal profits have been estimated at £3,371,000, which income seems likely to increase in future years. For saving life and property at sea, as well as for defensive purposes, our coast communication should be completed with the annual surplus postal profits. French trawlers, manned exclusively by naval reserve crews, fish all round Cornwall, the west and north-west Irish coasts, making frequent visits. The French Naval Reserve is intimately familiar with our Irish coasts, which in some situations are unguarded by coastguards and without telegraphs, except at a distance of upwards of 35 miles. Even then the "nearest" telegraph station may be only open from 8 a.m. to 8 p.m., and closed all Sunday. Mr. Lawrence-Hamilton, in addition to furnishing these pregnant statistics, further suggests that the United Kingdom could raise from our British fisherfolk a volunteer defensive naval reserve of about 100,000 men, and a volunteer defensive cadet reserve of 100,000 fisherboys.

A Sky Timepiece.—Our attention is called to an invention by which an ordinary clock is practically magnified to such a size as to permit of its being seen for a radius of 50 miles around. This is a big statement to make, and probably hardly credible at first, but it has an element of possibility in it. It is, we understand, a recent invention of Mr. H. Y. Dickinson, of 56, Gray's-inn-road, London, who also owns the patents. The actual time-indicating clockwork is the same size as an ordinary turret clock, but connected with this there is a second train of clockwork which is controlled by the clock proper, and is put in motion every minute, when it whizzes round (regulated by an ordinary fan governor) and actuates an electric flashing lens, in much the same way as the striking mechanism of an ordinary clock acts. The beam of light reflected into the sky goes through the movement of a striking hammer when the clock is indicating the even hour. This is, however, only one signal made by the apparatus. Another symbol is used for every complete interval of five minutes, and yet another for odd minutes. Thus, supposing the time to be 7.27, this would be denoted by the seven beats in the first instance, then five other signs (indicating 5 × 5 minutes), then two short, sharp flashes for the two odd minutes. This operation is gone through every minute, the signalling taking on an average about 10 seconds. Of course, it will be evident to anyone that the system of signal used can be modified to suit any conditions, and, further, that the code has only to be understood to enable anyone with a little practice to read this sky clock with ease. Such apparatus placed in the centre of this vast metropolis might be a great boon to the inhabitants, and that after a little practice the time would be read off as easily as from an ordinary time dial. There would be no excuse for the vagaries of time now indicated in most houses, and even public buildings, where if the timepiece is within a few minutes of the actual time it is allowed to pass. With this clock at work it would only be necessary to run to the front door to see the time so as to correct the kitchen clock, or for the City man catching his train in the evening to check his watch. At the present time many clocks in large offices and stations are electrically synchronised hourly from a standard clock, but this convenience has to be paid for, and is rather costly. Mr. Dickinson's clock would not only permit of clocks being synchronised, but watches too, and for no charge. We are afraid the inventor will have some difficulty in getting the authorities in London to take up the matter, but what a chance for some of the large advertising firms! A sum of money spent on a public benefit of this nature would keep the firm's name with which it was coupled before the public in a more lasting manner than could be gained from the ordinary advertising channels. The invention is worth trying, at any rate, at an exhibition. Mr. Dickinson had better get the Electrical Exhibition to take it up and give London "Crystal Palace time." If it were successful in London, it would be followed in all the most important cities throughout the world as a public necessity, and handsome royalties might be expected by the inventor. We believe something of the sort has been done in Sydney, but this, if we remember, is an hourly flash. We understand that the first of Mr. Dickinson's sky clocks is now in course of erection, so that the public will shortly have a chance of judging of the promised effect.

OUR PORTRAITS.

Jackson, Colonel R. Raynsford, born in 1823, is the son of the late Captain Jackson, R.N., J.P., of the county of Lancaster, honorary colonel of the 3rd Brigade of Lancashire Artillery Volunteers from 1861. He was partner in the extensive cotton spinning and manufacturing business of the late Sir Wm. Fielden, Bart., of which, after retirement of Colonel Montague Fielden, he subsequently became sole proprietor. He was chairman of the National Telephone Company from its formation early in 1881 until the amalgamation of the principal telephone companies into one company, which retained the name of the National Telephone Company, in May 1889, when he was elected, and has continued, vice-president of the company.

Holden, Captain Henry Capel Lofft, Royal Artillery. Born in Cheltenham on the 23rd January, 1856, passed the Royal Military Academy, Woolwich, and obtained his first commission in the Royal Artillery in August, 1875. He served in India from 1877 to 1881, and whilst there carried out a number of experiments in telephony and telegraphy, having been granted the singular favour of a license for a private line by the Government of India for this purpose. Since 1886 he has been in charge of the department for the proof of guns and experiments therewith in the Royal Arsenal, Woolwich, and he has invented and designed whilst there many electrical instruments connected with his profession. He was deputed by H.M. Secretary of State for War to visit and report upon the electrical appliances at the Paris Exhibition of 1889, as well as that at Frankfort in 1891.

Sketch of the Stand of the Acme Electric Works at the Crystal Palace.

Hammond, Robert. Born in 1850, and took up electrical engineering in connection with his Middlesbrough business in 1879. He is now the sole partner in the firm of Hammond and Co., electrical engineers, of 117, Bishopsgate-street Within, London, and Middlesbrough. He is the accepted candidate for the Hallam division of Sheffield. He was the first purchaser of a Brush concession, and for some time pushed the Brush business very vigorously, but as in those days the Brush Company had no reliable incandescent machine, he severed his connection with them and obtained the co-operation of Mr. Ferranti. Hammond and Co. devoted themselves in the early days to the lighting of iron works, steel rail mills, etc., and fitted installations into the principal iron works of the country. As early as 1881 Mr. Hammond took up the problem of the distribution of electricity from central stations, and founded the pioneer stations at Brighton, Eastbourne, and Hastings. In recent times he has laid down the West Brompton station of the House-to House Electric Light Supply Company, and one of the largest electric light stations on the Continent for the Electricity Supply Company for Spain at Madrid. He is now executing the contract which the Electrical Engineering Company of Ireland made with the Dublin Corporation.

Stuart, Captain A. M., of the Royal Engineers. Like many of his colleagues in that celebrated corps, he has had considerable experience with military electrical work. Entered the Royal Engineers in 1879, and was engaged in submarine mining and telegraph work from 1881 to 1884. During the succeeding years, from 1884 to 1887, experience was gained in London and on the Egyptian frontier in all that concerns military telegraphy. For the next two years Captain Stuart was with the southern division of the Post Office telegraphs, and since that time to the present has been assistant instructor in electricity at the School of Engineering, at Chatham.

Taylor, Colonel du Plat, although not now included within the ranks of electrical engineers, has claims to member-

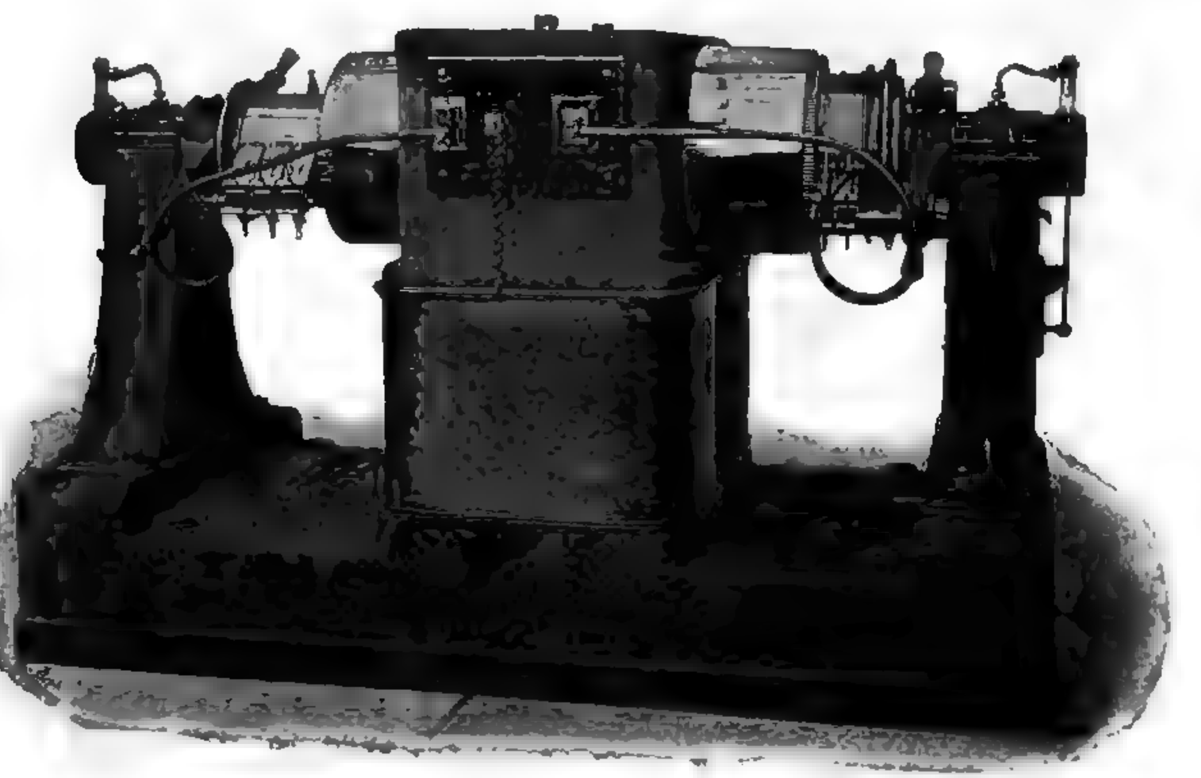
ship with the fraternity. His business life commenced under the ægis of the Postmaster-General, and so far his connection with the Post Office can hardly be said to have been severed, inasmuch as he is the colonel commanding the Post Office Volunteers.

THE CRYSTAL PALACE EXHIBITION.

We have so often referred to the enterprise of the Crystal Palace District Company in carrying out under great pressure the Sydenham-hill lighting station, and have described so much of the work, that only one important link remains practically unmentioned. We can now remove the veil and refer to the apparatus. Perhaps the one feature in the supply of current to the Crystal Palace by the District Company is the adoption of fairly high-pressure continuous currents generated at the central station and transformed downwards by continuous-current motor-generators at the distributing station. It is unnecessary in a more or less popular description of exhibits to enter into technical details that can be left for a future time, and undoubtedly a good deal of discussion will range around the use of this apparatus. The general reader knows that the use of motors with continuous currents has long been practical. Such motors are in use the world over, and great advances have been made in obtaining in one shape or other motors for alternate currents, but the use of such motors is not general. Restricting our remarks, then, to continuous currents, it is well known that electrical energy can be given to a motor and mechanical energy obtained therefrom. This mechanical energy can be used to turn another dynamo or to turn a lathe. In the motor-generator the mechanical energy obtained from the motor is used to turn a dynamo, and to simplify matters, both motor and dynamo are erected upon one shaft. It is simply a combination of two machines, but a combination which increases the efficiency of the apparatus as a whole. In the Crystal Palace building are nine of these motor-generators, eight of which are in use, as stated in our article of last week, by the Crystal Palace District Company, and are to be found under the floor of the main building. The ninth is to be found in the Machine Department, at the stand of the **Electric Construction Corporation**. The latter differs from the former in that it is self-starting—that is, requires no extraneous current to excite the magnets. The Palace machines, as illustrated herewith, are wound to give an output at the secondary terminals of 110 volts, 360 amperes, when supplied with primary current at an E.M.F. of 1,000 volts, and runs at a speed of 550 revolutions per minute. The efficiency is stated to be as high as 91 per cent. with full load, and over 81 per cent. down to one-third load. The bearings are fitted with specially-designed oil pumps so as to secure continuous lubrication, allowing the machine to be left for lengthened periods without attention. A similar machine to this has been running at the Chelsea Electricity Supply Company's station for the last 18 months, and recently a second one has been added. The company have also in hand a complete central station for Oxford, where high-tension continuous currents with these transformers has been adopted.

The Acme Electric Works, Stand 170, have an exceedingly prettily-arranged exhibit, which includes examples of their various makes of instruments, switches, and switchboards.

Messrs. Woodhouse and Rawson, Stand 103, at the south end of the North Nave, have a large exhibit of their various manufactures. It is rendered specially noticeable by reason of two large diamond-shaped pieces of wood which are suspended over it. Grooved letters, W. & R., are formed by fitting together pieces of silvered glass. In the grooves thus formed incandescent lamps, coloured alternately blue and red, are placed, and clockwork is arranged to alter the connections at certain intervals and so form the letters first with red-coloured lamps and then with blue. The diamond containing their initials is the company's well-known trade-mark.

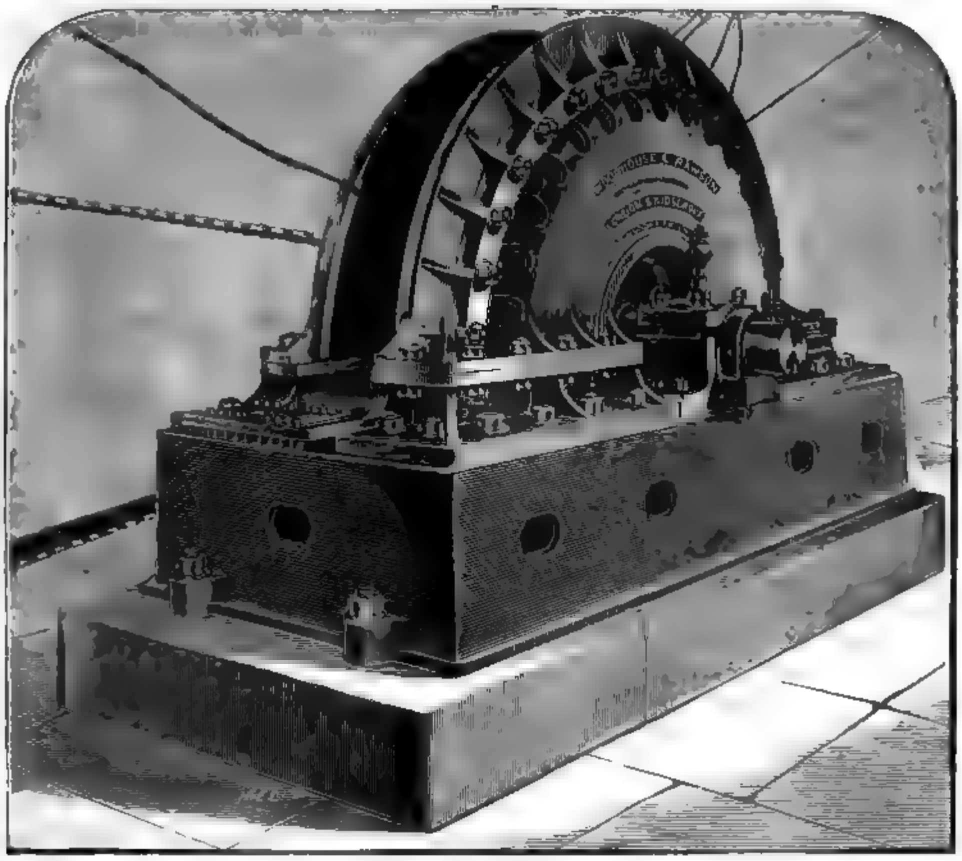


The Electric Construction Corporation's Motor Generator.

A prominent object in the stand is the Kingdon dynamo, illustrated herewith, which has more than once been fully described in our columns. In this type of alternator the armature and field magnet are both stationary, and the necessary alternations in magnetic field are obtained by revolving in front of them a large iron wheel. What is very much to the purpose is that this type of alternator is being used in central stations, as at Woking. In the exhibit it is driven by means of leather link belting by a Woodhouse and Rawson motor, supplied with current from the mains of the Crystal Palace and District Electric Lighting Company, Limited.

The necessity for a good motor for launch work led the company to design the "Woodhouse and Rawson," several sizes of which are shown. Special pains have been taken

to keep the centre of gravity as low as possible, and also to render the armature waterproof. These and other improvements, among which may be mentioned the use of carbon brushes, are claimed to have resulted in the production of a reliable motor which just now is receiving a good deal of attention. The uses of electromotors are daily increasing. It is only during the past year or two that Englishmen have begun to appreciate the many advantages of such machines. Their economy is now a well-established fact, and wherever an electric current is easily available, their application is daily extending. In the larger sizes, especially when intended for use as a dynamo, the design is slightly altered, the magnetising coil being placed at the side of the armature instead of the top.



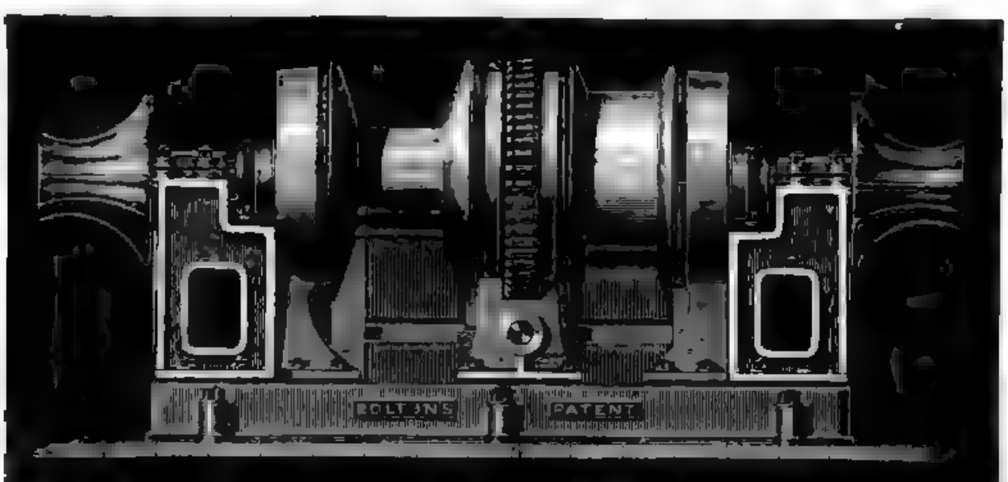
The Kingdon Dynamo.

One of Bolton's patent electric winches is exhibited in action. The axle of a Woodhouse and Rawson motor is attached to worm gearing, which reduces the speed to the required limit. These winches are specially suitable for use on board ships on account of their noiseless action. The winch consists of an electric motor, which is geared on to a centre gear drum. At each end of this drum, which is always revolving, the hoisting drums are gripped by friction. The only work the man in charge has to do is to put these drums in or out of gear. When in gear the load is hoisted and when out it is lowered by gravity.

To meet the demand for an electrical governor for controlling turbines and engines driving dynamos, a special form of the Porte-Manville type is shown. The variations in the strength of an electric current are made to actuate a ratchet-wheel, and so control the movements, either of the connecting-rod between the mechanical governor and the steam engine, the valves of a turbine, or a switch which varies the resistance in circuit in the exciting circuit of a dynamo.

Above the stand a crown of six Midget arc lamps is shown. These lamps, it is said, are rapidly becoming favourites for lighting small areas and large buildings, and form a very economical means of illumination. Hitherto the great unsteadiness of small arc lamps—*i.e.*, lamps of about 500 c.p.—have prevented their coming into use, but now that this difficulty has been overcome we may expect their use to rapidly increase.

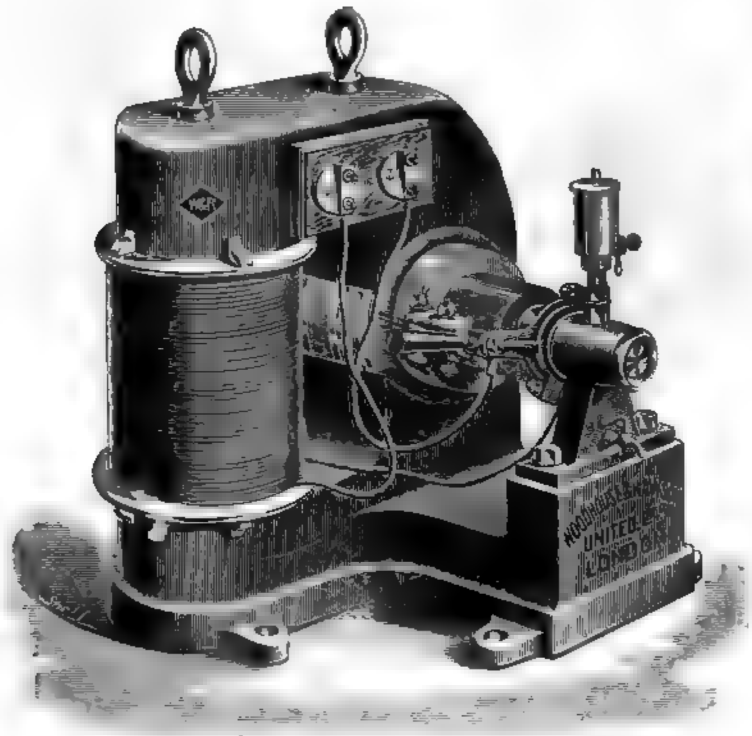
The company show various types of switches suitable for carrying large currents up to 1,000 amperes, or sufficient



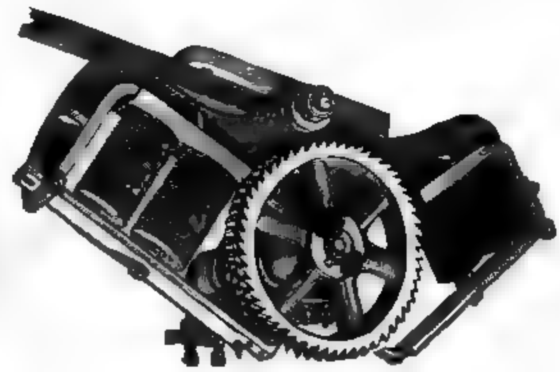
Electric Winch.

to light over 1,600 incandescent 16-c.p. lamps. Double-pole switches have lately come into use, and several special designs of these are shown. These are suited for installations where very large currents are used; while other designs are suitable for smaller currents. Where high electrical pressures are used, the type illustrated is found convenient.

Some years ago the company introduced the Cunynghame magnetic cut-out. This instrument, which has been widely used and appreciated, is inserted in an electric circuit for the purpose of breaking connection when the current exceeds a predetermined limit. The type now adopted and shown at the Palace is slightly different from the original design. The current of electricity in passing around the pivoted coil creates a magnetic field, and tends to move in such a direction as to enclose more of the iron core. As the current increases this tendency to move becomes stronger, until at last the

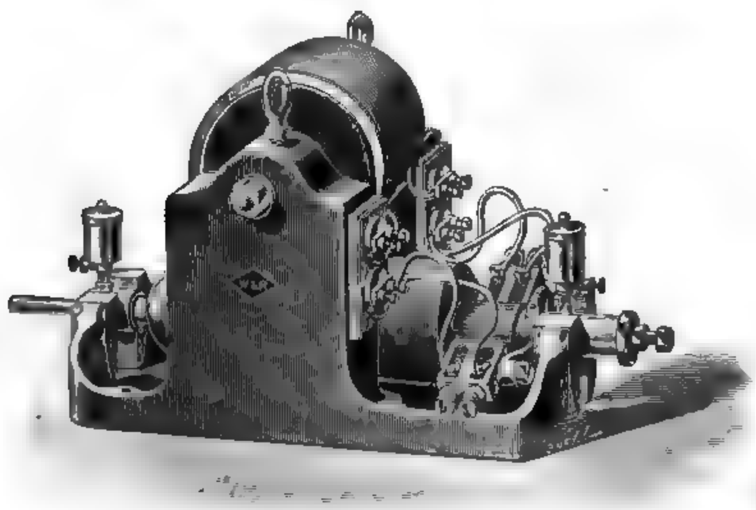


Woodhouse and Rawson Dynamo.

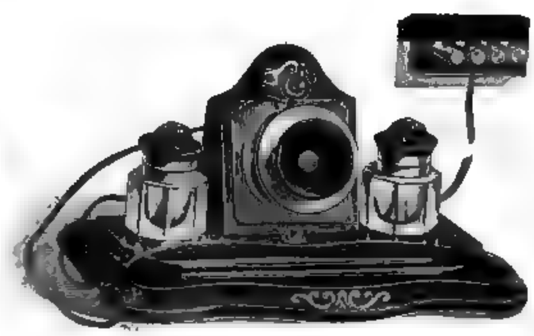


Porte-Manville Governor.

Magnetic Cut-Out.



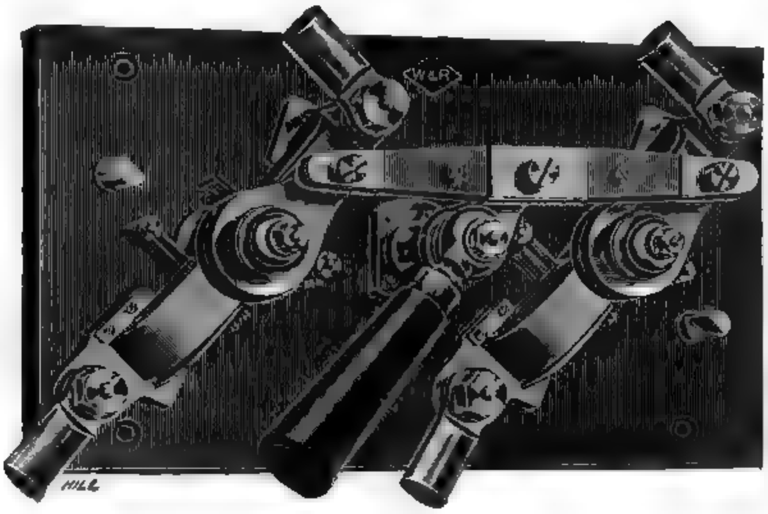
Woodhouse and Rawson Motor



Ebonised Inkstand Set

Clock Cut-in.

Lavatory Switch.



Double-Pole Switch. Crossbar Pattern.

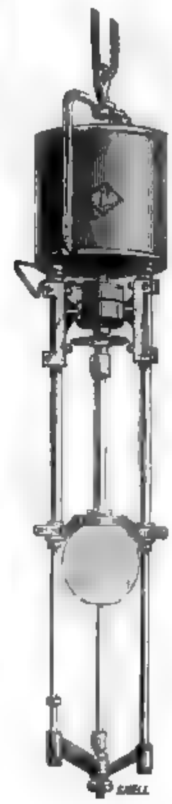
Double-Pole Switch. New Type.

High-Tension Double-Pole Switch.

The New "Thorough" Telephone Set.

Switchboard.

Telephone Transmitter.



Midget Arc Lamp.

ends are quite withdrawn from the mercury, and the centre of gravity of the coil is moved to the other side of the pivoting point, and the coil falls over by the force of gravity, thus permanently breaking the circuit. These instruments are of great use for such purposes as charging accumulators, protecting an electric light installation from risk of excess current should the engine be overrun, and many other contingencies which electrical engineers often meet with. These are shown in all sizes, one collection of six forming a complete series capable of breaking the circuit at any strength from one to 1,000 amperes.

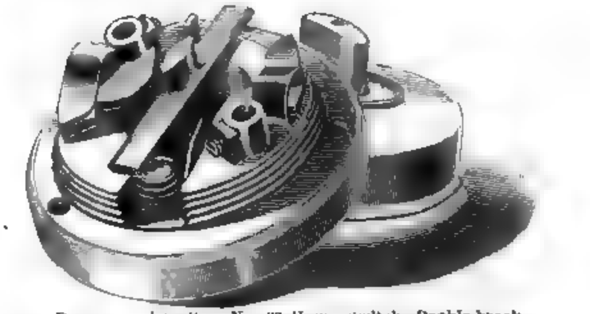
A novelty just introduced is a contrivance for switching in an electric circuit at any predetermined time. A clock is set to a certain hour, and it is so arranged that its movements release a pivoted arm, which, when free, fall into two mercury-cups, and make electric contact. Another useful appliance is the lavatory switch. It is designed for the purpose of economising the use of lamps, and is affixed to the door frame so that alternate openings and closings of the door turn the light on or off.

The expiry of some of the more important telephone patents having opened the telephone market, this company have introduced several new forms of instruments, and are making domestic telephony one of their chief specialities. The illustrations give some idea of the designs exhibited, which are loud-speaking and reliable.

The switchboard illustrated is one of the latest designs, and contains several novel features. It is intended for use with compound-wound electromotors, and the locking arrangements of the switch are so arranged to first of all put the series-wound coils in a position to increase the strength of the magnetic field; and afterwards, when the magnets are fully excited, to reverse the direction of the flow of current through them, so as to allow them to perform their proper compounding function. The handles are locked by the vulcanised fibre rings, so that it is impossible to turn them in any other order than that necessary for performing the necessary changes in the electrical connections. The other exhibits on this stand are well worth careful examination.

At the end of the South Nave, near the fountains, is the exhibit of **Messrs. Dorman and Smith,** the well-known manufacturers of electric switches and fittings. It is well worth a visit from electrical engineers, as me new and ingenious types of switches and accessories are shown. Small switches in brass and porcelain, the latter artistically decorated, are shown in great variety. The best-known of the switches is the ordinary house type, with quick break and sudden release handle, of which some 100,000 are in use. One of the latest introductions is that here illustrated, No. 60 pattern. The contact arm, after breaking current, is quietly brought to rest by the same spring which accelerates its movement when switching off the current—thus securing a non-percussive action, which dispenses with the jarring which is so often a source of trouble by loosening the wires in the terminals. A very useful and rather peculiar double-pole main switch is also exhibited. They are made of gunmetal on paraffined slate. They have an instantaneous break, however slowly the handle may be turned, and this is secured either by a tension spring or a coiled spring round the shaft, the latter being now preferred. The action is very satisfactory and the workmanship excellent. We also show a six-way accumulator switch, the change in contacts of which are made instantaneously on moving the handle, thus avoiding the short-circuiting of cells.

Dorman and Smith's Quick-break Switch.



Dorman and Smith's No. 60 House Switch, Double-break.

Dorman and Smith's Carbon Break Switch.

Dorman and Smith's Double-Pole Main Switches.

Still another kind of switch which should be mentioned is shown at this exhibit. Messrs. Dorman and Smith are sole makers of Siemens patent carbon contact switch. The final break of this switch is between two carbon blocks, and this arrangement is useful in keeping the metallic contacts clean and free from burning. A D. and S. spring is used to prevent the contact from remaining in an arcing position. Lampholders shown by this firm are worthy of attention. One or two of the D. and S. patterns are much appreciated by the trade. Samples of their wall-sockets (double peg, and also concentric), ceiling roses with their patent arrangement for taking the strain off the wires, besides cut-outs of all kinds, are exhibited. A handsome and very serviceable balance lamp pendant is shown, with cut-glass globe—any kind of shade can, of course, be used therewith. Brass and cast-iron ship and mill fittings of all descriptions, including Sunbeam lamp fittings, are exhibited, and many of these being specially designed for colliery lighting. Switchboards, of which Dorman and Smith make many varieties, are represented by a large enamelled board in walnut frame, mounted with their main switches of various types.

THE

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NOTICE.

With this issue of the Paper is given a Supplement containing Portraits, taken from photographs, of **Colonel R. Raynsford Jackson, Colonel du Plat Taylor, Captain H. C. L. Holden, Captain A. M. Stuart, and Mr. Robert Hammond.**

Every reader should see that he gets this Supplement, and non-delivery with the Paper should be reported at the Publishing Office.

DEPUTATIONS AT THE PALACE.

The notice-board at the Crystal Palace will, from now to the end of the Exhibition seldom, be free from a notice that such and such a deputation will visit the Palace on certain days. Yesterday and to-day the Mayor and the members of the Derby Corporation have been seeking information. Last week we recorded the visit of a deputation from Nottingham, and prior to that, from Blackpool. Other deputations are to follow, each seeking for certain information. We have already suggested to exhibitors that they be well represented and prepared to receive such visitors. It may, however, be more necessary to advise the deputations than the exhibitors. The latter are sellers, and keen to do business; the former are likely purchasers, and every effort will naturally be made to give them a bias in this or that direction. No doubt the sellers are somewhat anxious to book definite orders, but instead of benefiting themselves they may do harm by showing too great an eagerness. They know that the patronage of one town will amply repay for the trouble, anxiety, and expense of the exhibition, and would like an immediate contract as the result. Corporation business does not move so rapidly as all this. Deputations do not come provided with a commission to order a central station and all the appurtenances thereof. They come to get provided with answers to opponents, and arguments to induce constituents to agree to follow the stream of progress. It must be regretted that several well-known firms have held aloof from this Exhibition. The time is very opportune. Men's minds are turning with favour towards electric lighting, and those who exhibit at the Palace will certainly be put in a favourable position in connection with those places from which deputations come. For example, one of the most important questions with which members of corporations will concern themselves, is that of mains. What kind of mains will at the same time be efficient and give least trouble in laying and in maintenance? Electric light people must not expect the roads and streets of a town to be given up to their tender mercies for any length of time. We have heard many absurd remarks as to the requirements of borough engineers or surveyors who watch over the interests of the corporation, but in the matter of laying of mains many such engineers could give valuable information. Exhibitors, as a whole, have not thought the question of mains of sufficient importance to show actual examples, but the exceptions, Messrs. Crompton and Messrs. Siemens, have short lengths of mains as they suggest mains should be laid. Where corporations become their own undertakers, they will attempt to obtain that system which conforms closest to their views in not at any time interfering much with ordinary street traffic. Messrs. Siemens should have the benefit of the results at Bradford. Deputations should insist upon authoritative information. This can undoubtedly be forthcoming, and if, as we presume, it is quite satisfactory may largely influence the use of armoured cable, and

a simple trench with no provision for hauling out a cable for repairs. It may be much cheaper and better in all respects to follow such a system when the conditions are favourable, than to use a more costly one. Messrs. Crompton, again, have the experience obtained at Kensington and elsewhere, and should be able to show under what circumstances the naked copper strips and concrete channel is best. Sufficient time has not passed to hope to obtain authentic statistics as to the faults which develop in electric light mains. It is absolutely certain, however, that faults do and will occur, and the repair of these will become one of the recognised duties of central station work. The initial cost of laying the mains must be considered in connection with their maintenance, for though one way may be cheaper than another, the tables may in time be turned and the dearest become the cheapest, through cost of maintenance. Our advice, then, to deputations is to get all the information possible on this subject. It is almost entirely a matter of business, and requires little scientific knowledge. Of course the decision as to the system of distribution and the calculation of the size of mains is another matter. Each deputation will have a definite object in view, probably the lighting of a particular town. They will be able to give approximately the area to be lighted ; the class of lighting—residential, factory, or street ; the position at which a central station might be put ; the consumption of gas in the district ; the cost of gas and its quality. They will expect in return some fairly definite information as to what could be done with electric light, the unit of power to be employed, the kind of prime mover to be employed, the kind of dynamo, and the reasons therefor. The more information these deputations can obtain, the better able will they be to convince their fellow-townsmen of the advantages of electric lighting. It may not be amiss to warn exhibitors to make it quite clear as to which are their exhibits and which not. Even now there are arc lamps and arc lamps. Visitors will not fail to recognise this, and those that are so-so, must belong to the right owners. The Machinery Department contains some widely divergent types of prime motor, an exceedingly interesting display, as are also the combinations of engine and dynamo. Much of the work of next winter will depend upon the impressions received now.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

CRYSTAL PALACE EXHIBITION.

SIR,—On revisiting the Electrical Exhibition at the Crystal Palace, I was surprised to find how greatly it had improved. Everything is now in full swing. The spirit of emulation seems to be spreading among the exhibitors, for if one has a pump or big accumulator, or even a crane, another exhibitor must have one like it or bigger, if possible. The result is that most of the stands are getting crammed with interesting objects, although in one case the fascinating smiles of the charming maiden who presides over the Hedgehog more than compensates for the paucity of the exhibit.

I notice that anything that makes a noise or goes round is sure to attract. When the young gentleman in charge switches on the field current to the Kingdon alternator and makes it roar, a crowd collects immediately, and two minutes after the electric crane starts you cannot get near it. The telephone-room is doing a tremendous business, and it is very interesting when the organ is not playing, and altogether, what with the awful diver that frightens the children at one end, the awfuller choir that frightens the old ladies at the other, all visitors seem thoroughly pleased with the evening's entertainment.—Yours, etc., X.

THE LIFE OF INCANDESCENT LAMPS.

SIR,—You always take such a strong interest in all practical questions that I am tempted to trespass on your space in order to ventilate one that has been perplexing me a great deal lately, and that is, the short duration of Edison-Swan incandescent lamps. From a little enquiry I have made, I am led to believe that other electrical engineers have been also noticing this during the last few months, and it would be most valuable if through your courtesy opinions could be exchanged on this point. In plain words, is it or is it not the case that lamps are not standing as they used to do ? To those engaged in installation work this is a serious question, as nothing disgusts a customer more than, after having gone to a certain expense in an installation, to find that he is obliged almost every week to be putting in one or more new lamps. It may be that my recent experiences are unique, but I don't think so, and, at all events, should be grateful to any practical men with large opportunities of judging who would give their views.—Yours, etc., EXPECTANS.

Feb. 23, 1892.

ELECTRIC TRAMWAYS.

SIR,—In your issue of the 19th inst. you publish the first instalment of a paper by Mr. W. G. Carey, on "Electric Tramways on the Overhead or Trolley Wire System," and we shall be obliged by your giving us space to reply to some of his remarks in regard to the use of conduits in lieu of overhead wires for tramway traction. Mr. Carey remarks "that it cannot be doubted that many of the communities are deterred from adopting it [electric traction] only by their prejudice against overhead wires," and at the same time his paper endeavours to show that no other method of electric traction on tramways is practicable. His condemnation of conduits is wholesale and complete, but we venture to think scarcely accurate. He considers there is little reason to hope that "an open-slotted conduit could ever be made a success in our streets, its fatal weakness being the impossibility of keeping the conduit free from mud and water." As a matter of fact successful conduits have been constructed and worked—for instance, at Blackpool and in Budapest, as well as at Northfleet, where a conduit line was built which was absolutely satisfactory both mechanically and as regards the question of interference through mud and water. Perhaps, however, Mr. Carey prefers to confine himself to the American failures, where, he says, "thousands of pounds were expended on four practical experiments." We have seen a sample of the conduit that has been used in American attempts, and if this was a fair example of the four practical experiments we are not at all surprised at their being absolute failures. We agree with Mr. Carey as to the importance of proper provision being made for keeping the conduit free from wet and dirt, but we do not admit that this presents any insuperable difficulty. The conduit system which we advocate where overhead wires are not permitted has special provision in regard to keeping the conduit clean, in addition to other improvements, and how far we have succeeded in this direction is, we think, fairly well indicated by the remarks which occurred in your issue of April 25, 1890, in regard to our system, where, after pointing out the requirements in underground conduits, you were good enough to say : "*All these points are obtained in the new system with no chance of stoppage through mud or dirt.*" We recognise the advantages of the overhead system of traction, and, as engineers and not contractors, recommend it, where permissible, on account of the somewhat smaller

capital involved, but we protest against a statement that, apart from this increased capital cost, equally good results cannot be secured by the use of an efficient conduit system. No doubt Mr. Carey, from his connection with the Thomson-Houston Company, desires to cry up his wares and to depreciate other methods of traction, but he should surely have some regard to facts, although they are doubtless inconvenient to him.—Yours, etc.,

WALLER AND MANVILLE.

Victoria-street, Westminster, S.W.,
February 22, 1892.

A CORRECTION.

SIR,—Respecting your article under the heading of "Woodhouse and Rawson" in your issue of Feb. 12, we beg that you will kindly correct remarks made in same which carry a false impression with regard to our work—namely, that the model of the electric launch referred to is a model of the "Glow-worm," which was built by us for Mr. Andrews Pears, and not by the Thames Electric and Steam Launch Company; and also that we have no connection whatever with the Thames Electric and Steam Launch Company, which your article might lead readers to infer. We should be obliged by your kindly inserting this contradiction in your next issue.—Yours, etc.,

WOODHOUSE AND RAWSON UNITED, LIMITED.

88, Queen Victoria-street, E.C.,
February 18, 1892.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

IV.

(Continued from page 159.)

MEASUREMENT OF ELECTRICAL RESISTANCE.

Having now briefly described the several electrical units, and ascertained the nature and characteristics of electrical resistance, we shall proceed to describe and illustrate the different methods used for determining the resistances of various substances, and the forms of apparatus usually employed in these measurements. Current indicators such as simple detectors and zero instruments play a most important part in these determinations, but as the description of these comes naturally under the head of current-measuring instruments, we shall merely briefly refer to them here, leaving the full description of their construction, and the theoretical considerations involved in their manufacture, until current detectors and zero instruments are being considered.

Resistance of Conductors.—Before commencing to determine accurately the resistance of a conductor, it is advisable to ascertain whether this resistance is likely to be a high or a low one. Perhaps one of the best methods for determining approximately the resistance of a conductor is that known as the *Substitution Method.* This method can be used either with or without the assistance of a shunt; in the former case it is usually designated the *Simple Substitution Method,* and in the latter, the *Shunt Substitution Method.* For either of these two methods, the necessary apparatus is: a sensitive galvanometer, such as a Thomson reflecting, a d'Arsonval, or a Deprez; one or two low-resistance battery cells, capable of giving out current without material variation of potential, such as the well-known Daniell cell, or preferably cells of the lead secondary type; a variable known resistance, which may be in the form of a box containing calibrated resistances, a metre bridge, or a graduated rheostat; and a suitable contact-maker. If a variable known resistance is not available, an unvariable one, such as a coil of wire whose resistance is known, may be used instead, as explained. A convenient arrangement of the apparatus for measurements by the Simple Substitution Method is illustrated diagrammatically in Fig. 1.

Having fitted up the apparatus as shown with the resistance to be measured, R, in circuit, note the deflection of the galvanometer on the completion of the circuit. Now remove the unknown resistance, R, and substitute for it the variable known resistance, R_1, and so regulate it that, on again completing the circuit, the galvanometer needle gives exactly the same deflection as before. This now indicates that the resistance of the whole circuit is just equal to that in the former case, so that the resistance shown by R_1 must be the same as R, the resistance being determined, or

$$R = R_1.$$

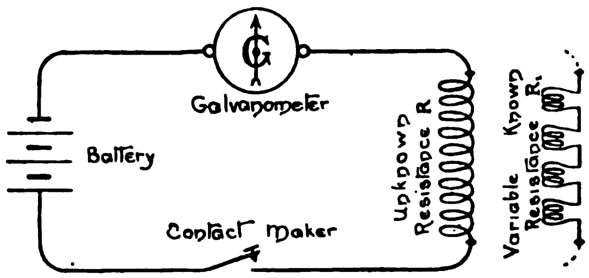


FIG. 1.—Simple Substitution Method.

This arrangement can also be employed when the known resistance, R_1, is not variable, if the scale of the galvanometer is accurately calibrated. For this purpose the resistance, R_G, of the galvanometer, and R_B, of the battery must be known.

Then if d be the galvanometer deflection when the unknown resistance, R, is in circuit,

and d_1 be that with the known resistance, R_1;

since, by Ohm's law, the whole resistance of the circuit in each case is inversely proportional to the current flowing, and therefore to the galvanometer deflection, we have—

$$\frac{R + R_G + R_B}{R_1 + R_G + R_B} = \frac{d_1}{d}$$

$$\text{and } \therefore R = \frac{d_1}{d}(R_1 + R_G + R_B) - (R_G + R_B).$$

Usually, in measuring resistances by this method, the internal resistance of the battery employed is but the fractional part of an ohm, while the resistance of the galvanometer would probably be some hundreds of ohms, so that the former is negligibly small in comparison with the latter. Then, instead of the foregoing formula, we may write:

$$R = \frac{d_1}{d}(R_1 + R_G) - R_G.$$

For measurements by the *Shunt Substitution Method,* the apparatus is arranged as indicated in Fig. 2.

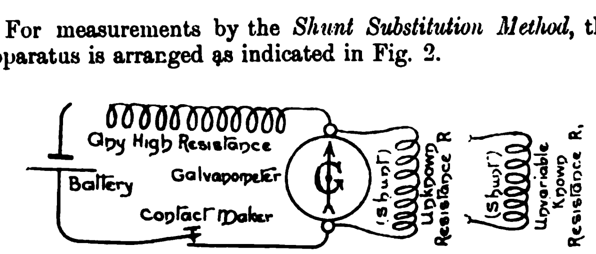


FIG. 2.—Shunt Substitution Method.

In this case the resistance to be measured, R, is connected up as a shunt to a sensitive high-resistance galvanometer, which forms part of a circuit in which are also a single voltaic cell and an added high resistance, as shown. It will be seen from this arrangement that the actual current flowing through the galvanometer and shunt together will be very small, and that most of this current will flow through the shunt itself, owing to its own resistance being low, relatively to that of the high-resistance galvanometer. Owing to the high resistance in the main circuit, any alteration in the shunt itself makes very little difference to the total current passing through the shunt and galvanometer together, its chief effect being simply to proportionally vary the amount of this current which flows through the galva-

nometer, so that the reading of the galvanometer is really a measure of the resistance of the shunt.

Thus, if d be the galvanometer deflection when the unknown resistance, R, constitutes the shunt,

and d_1 be that when the known resistance, R_1, is substituted for it;

then we have—

$$\frac{R}{R_1} = \frac{d}{d_1}$$

$$\text{and } \therefore R = R_1 . \frac{d}{d_1}.$$

ELECTRIC TRAMWAYS ON THE OVERHEAD OR TROLLEY WIRE SYSTEM.*

BY W. GIBSON CAREY.

(Continued from page 188.)

Three methods of supporting the trolley wire are pursued depending upon the position of the tracks in the roadways. By far the most common of these is what is known as the "span-wire" system, in which the poles are planted at the edge of the footpath on either side of the street, and the trolley wire hung from a span wire stretched between them. On suburban roads where ornamentation is not necessary, wooden poles are usually used as, in the United States at least, they are far less expensive, and the insulation which they interpose between the trolley and the ground is an additional safeguard against accidents. In city streets, however, the use of wooden poles, which must of necessity be larger and more unsightly, is rarely allowed, and iron poles of various designs, often very handsome and ornamental, are used. The best of these are made of three sections of tubing, of about 6in., 5in., and 4in. diameter respectively. They are firmly bedded 6ft. deep in concrete, and must be strong enough to stand the lateral strain of the span wire without a greater deflection than 6in. at the top. Into the top of the pole is fitted a wooden plug boiled in paraffin and protected by a cast-iron cap. This serves to insulate the span wires from the ground. The span wires should be of No. 5 galvanised steel, and where an uncommon strain occurs two of these may be advantageously twisted together into a cable.

The method of putting up span wires is as follows: One end of the wire is securely fastened to an eye-bolt in the insulator at the top of the pole by means of an American telegraph splice, or one of the many special devices made for the purpose. The other end is then carried to the top of the opposite pole and the two poles are pulled together by means of a block and fall, or by a ratchet hauling clamp, until there is a strain on the span wire of 800lb. or 900lb. The span wire is then made into the eye-bolt on the second pole in the same manner as on the other. It is absolutely necessary that this apparently great strain should be put upon the span wire, or otherwise it will have a sag when the weight of the trolley wire comes upon it, which is fatal to a neat appearance of the line. The hangers or supporting devices used vary greatly in design to meet the requirements of special cases, but too much stress cannot be laid upon the importance of making them of ample strength. It is important, also, that all hangers and insulators should be made with regard to uniformity. The only part liable to deterioration is the insulators. These should therefore be made of a standard pattern, and the hangers arranged for their reception. In this way any fault can at once be remedied at a trifling cost. The hangers are placed in position by means of a plumb-bob, and should be so arranged that the trolley wire will come as nearly as possible over the centre of the track throughout its entire length. On curves the chords, where possible, should be made so short that the trolley wire is in no place more than a few inches out of the centre. When the hangers are in position, the trolley wire is stretched loosely along and hung temporarily from the span wires, and then pulled up tight by means of a block and fall. Lugs, known as ears, with a groove milled out along the bottom side to fit the wire, are then soldered on to the trolley wire beneath the span wires. These ears are arranged for the reception of an insulated bolt, the head of which is held firmly in the hanger, and the trolley wire is thus securely fastened to the span and thoroughly insulated therefrom. We have now between the trolley wire and the ground the insulation in the hanger itself, which may be of ebonite or moulded mica, and the wooden plug in the top of the pole. This is, in actual practice, so perfect that even in very wet weather the insulation resistance will be not less than 15,000 to 20,000 ohms per mile. It will be readily understood that no rule can be laid down for the design of the overhead wiring. The length of the spans of the trolley wire, the position of the poles, span wires, and pull-offs, etc., must be designed to suit each special case, and unless this is most carefully done troubles from breaking wires or unsatisfactory working of the trolley is sure to follow. On single-track roads, with passing places, frogs of various design are used. These are so made that the trolley will automatically follow the wire, and need no attention whatever from the conductor of the car. Where necessary, supplementary feed-wires are carried either on the poles, or, preferably, in armoured cables laid underground and connected at intervals to the trolley wire.

As has been said, no rule can be laid down for the distance between the poles, but this should in no case exceed 125ft. On suburban roads, where the track is principally straight, this distance can be pretty closely adhered to, but upon curves and city streets it must often be considerably reduced, averaging usually from 100ft. to 120ft. In the case of double-track roads, where the width of street permits, the tracks may be laid further apart than is usual, and poles planted between them. This is certainly by far the handsomest method of overhead construction. In the first place, it permits the use of only half the number of poles that would be necessary with the span-wire system, and it does away altogether with the necessity for span wires. The poles where this system is carried out may also be used for arc or incandescent lighting of the streets. The trolley wire is supported by brackets extending over the track on either side of the pole, and the feed-wires may be carried as usual on the poles, although an underground system of feeders is preferable. On suburban tramways running along country roads, the track is usually laid on one side of the road, and in that case a system of bracket suspension should always be carried out. If the line is single, the poles may be planted along the side of the track, and the trolley wire supported from single brackets, as in the case of centre-pole suspension.

Owing to the greater weight of the electric car, and to the fact that the power is applied to the wheels and not to a draw-bar, the permanent way, where electricity is used, must be of a more substantial character than is usually considered necessary in cases of animal traction. No girder-rail weighing less than 65lb. to the yard should ever be used. The necessity for absolute thoroughness in track construction cannot be too strongly expressed, for cheap and careless work here will entail, not only continual repairs to the track itself, but a rapid deterioration of the rolling-stock, and an increased coal bill. This fact is so evident that it would appear hardly necessary to refer to it, and yet there are scores of roads in operation to-day whose dividends are continually reduced by expenses traceable directly to faulty track construction.

A most important part of electric tramways is the thorough bonding of the rails, in order to secure a low resistance in the return circuit. In the first place, a supplementary return wire should in every case be laid along the track and efficiently connected to every length of rail throughout the road. The vast importance of this is not even to-day thoroughly recognised by very many tramway companies, but it is certain that any neglect in this direction will in every case mean undue loss of power on the line. No rule for track-wiring can be laid down that will suit every case, but in general it may be said that a wire at least as large as the trolley wire should be used to supplement the conductivity of the rails, and

* Paper read before the Royal Engineers.

that the latter should be efficiently grounded at several points throughout the line by means of copper or iron plates of large superficial area buried at points where they will be always in moist ground. The number of these grounds will depend largely upon local conditions, and upon the effectiveness of each. Advantage should be taken of every opportunity for connecting to gas or water pipes. The most important of these grounds is at the power station, and here too much care cannot be exercised. The cross-section of the wire connecting the track to the power station should be as great as that of all the feed-wires leaving the station. The chemistry of the soil must decide what is the best material to be used for bond wires, but in most cases copper, on account of its higher conductivity, is preferable. Experiments in some places have shown that galvanised iron is less liable to corrosion, but, where possible, copper should always be used, and should in every case be thoroughly tinned. The bond wires are firmly keyed to the rails in holes drilled for the purpose by means of channel pins, and also soldered strongly to the main track return. Several methods of bonding the rails have been used, but in any case good workmanship is of the utmost importance.

Turning now to the power station, we find certain indispensable features which were almost unknown in central stations until the advent of the electric car. The electric tramway may be said to be responsible for the high-speed power steam engine. It is important that the units of power in a generating station should be as large as is consistent with the safe operation of the road, and that each unit should be entirely independent of all the others. These requirements can best be met by the use of direct-belted engines, and there can be but little excuse for the employment of countershafting except in the case of enormous roads, where very large engines may be used, without a risk of a great percentage of the total power being disabled in the case of accident. In such cases large economical engines of the Corliss type belted to countershafting may advantageously be used. In the great West End power station at Boston, which, when completed, will have a maximum output capacity of 26,000 h.p., this plan has been adopted, and great economy secured by the use of 2,000-h.p. engines. The tendency, however, is towards the use of larger dynamos, and direct belting, or even direct coupling, at the cost of a sacrifice of weight efficiency, the economy of space effected thereby being an additional reason for the move in this direction.

The severity of the service imposed upon engines in tramway work, which is perhaps only equalled by certain work in rolling-mills, as well as the increased speed required for direct belting, necessitates extra heavy construction, bearings of greater size and length, and more ample flywheel capacity. The failure of builders to fully appreciate the conditions which the work imposed has been responsible for troubles, in many cases, which have tended to bring high speeds into disrepute. The excellent automatic engines that are now turned out by several manufacturers are, however, quite as reliable as other types, having been built especially for the work they are expected to do. Experience in every class of work has taught us the cost of poor steam engineering, and the tramway company which puts in inadequate apparatus will soon find itself in the interesting position of having to put up with exorbitant operating expenses, or else rebuild its entire plant. Where possible, and water can be had, compound condensing engines should always be used. There are very few places where coal is so cheap that 40 per cent. of the coal bill would not pay the interest on the difference in cost between compound condensing and single-cylinder engines.

Other things being equal, the tandem form of compound engines is to be preferred on account of its smaller number of moving parts. Where the cylinders are placed side by side, two sets of working parts are required, double the risk of breakage encountered, more oil used in lubrication, and more power expended in overcoming the friction in the engine itself. Another great point in favour of the tandem engine, especially in tramway work, is that on light loads, the low-pressure cylinder of the double engine, on account of the early cut-off, will receive comparatively little steam as exhaust from the high pressure. There will be, therefore, no compression in the low-pressure cylinder, and a pounding and loosening of all working parts will ensue. This difficulty is entirely avoided in the tandem engine, both pistons being on one rod, and the high-pressure always cushioned. The governor must be quick-acting and yet not too sensitive, and the variation in speed between no load and full load should be within 2 per cent. at the outside, and it is quite possible with engines operating at from 200 to 250 revolutions per minute to do even better than this. This close regulation can only be obtained by the allowance of very great flywheel capacity, and in some of the engines now built for tramway work the flywheels alone weigh nearly as much as the lighter engines of equal powers complete. With this class of engine, in which the driving wheels are from 6ft. to 7ft. in diameter for sizes of from 100 h.p. to 300 h.p., the engines and dynamos should be set not less than 20ft. apart between centres, and even somewhat greater distances than this are advisable where space is not of great importance. Jockey pulleys are an abomination, and tight belts, especially with varying loads, are a source of endless trouble, and besides this, the elasticity of long belts which can be run very loose is an aid to the governor, second only in importance to heavy flywheels. In calculating the steam power required, an allowance of 20 per cent. above the rated power of the dynamos should be made in order that a constant speed may be maintained under momentary excessive loads. On a properly-designed generating plant these unusual loads will not be of more than a few seconds duration, but it is a bad practice to have your engines constantly working up to their maximum capacity.

Of boilers little need be said. The opinions of engineers differ greatly as to which type is most suitable for tramway requirements, and examples of each class are found, showing under careful management an economy with which no fault can be found.

The question of generators is one that is closely allied to that of the engines, and in discussing the latter reference was made to the tendency towards larger machines which present tramway practice shows. It must be understood, however, that this applies only to the case of large installations, and must not be carried to such a point that an accident at the station will cause a shortage of power on the line. Reserve power in the generating station is of the utmost importance, and the units should be of such a size that this reserve can be economically provided. Many years' experience in direct-current incandescent lighting, which, as far as the generators are concerned, differs but little, except in the matter of voltage, from tramway work, has paved the way to the production of dynamos whose reliability seems to be all that can be desired. Future development will probably be in the direction of the production of larger slow-running multipolar machines which will lend themselves to direct coupling, but the generator of to-day is by far the most perfect feature of tramways installations. It is imperative for the satisfactory operation of the motors that a constant difference of potential should be maintained on the line under all conditions of load, and to this end the generators must be compound wound and perfectly self-regulating. An E.M.F. of 500 volts is universally used in the United States. It is desirable, in order to avoid carrying enormous currents, that the E.M.F. employed should be as high as practicable, and this figure has been adopted as well within the limit of safety. The arrangement of the switchboard should be such as to give the utmost flexibility in the operation of the station, and to allow the instant cutting out of any particular machine or the transfer of the load from one machine to another.

(To be continued.)

Rheumatism and Electricity.—Mr. Grigg, of 33, Eastbourne-terrace, W., has a medical institute where electricity is applied successfully, we are told, to the relief and cure of rheumatism, and we are in receipt of some testimonials there anent. Rheumatism is a dolorous and elusory complaint; let us hope electricity has some effect in dislodging this enemy of mankind.

SOME EXPERIMENTAL INVESTIGATIONS OF ALTERNATE CURRENTS.*

BY ALEXANDER SIEMENS.

(Concluded from page 189.)

As materials are important items in the cost of a transformer, the consideration of the first point shows the desirability of employing a strong induction. A similar conclusion will be drawn from the investigation of the relation between the induction and the drop of difference of potential in the secondary circuit of the series of transformers. As they are all supposed to give the same current, the drop from no load to full load will be in proportion to the resistance of the circuit. This resistance is in proportion to the weight of copper employed, as all the transformers are assumed to be wound with wire of the same diameter. The curve (8) giving the weight of copper at different inductions will therefore also indicate, in comparison with the normal transformer, the variation in the drop of potential between no load and full load under the same circumstances.

In order to determine the variation of the efficiency of the transformers under investigation, it is necessary to treat separately the losses in the iron and in the copper. The former can be found by the aid of the curves on Diagram I., in combination with the curve giving the weight of iron necessary at the various inductions. An example will best illustrate how this loss is ascertained in a case where the total mass of the iron is worked at the same induction, produced by a current of a frequency equal to 100 complete periods per second, the iron mass being composed of 1 mm. wires. The loss in the normal transformer working with an induction B = 5,000, and with a weight of iron = 1cwt., is 309·6 watts, according to Diagram I. For another transformer working with an induction B = 2,500, the weight of iron, as shown by the curve (7), has to be increased to 2cwt.; at the same time the loss per cwt. is reduced to 126·8 watts, or the total loss is reduced to 253·6 watts.

In a similar manner the losses for the different inductions have been calculated, and the results are embodied in a curve (9), which indicates that the loss of energy in the cores of transformers increases with the strength of induction, at first rapidly, but after the induction has reached a value of B = 1,000 the increase is very slow. As far as the loss of energy in the iron goes, it is therefore of not much consequence what induction between 1,000 and 5,000 lines per square centimetre is used. The influence of the strength of induction on the loss of energy in the copper can be shown in the simplest manner by comparing this loss in the normal transformers designed for 5,000 lines with the loss in the other transformers of the series.

There are evidently three possible cases for the normal transformer. The loss in the copper may be equal to the loss in the iron, or it may be greater, or it may be less. For each of these cases a curve can be plotted showing the sum of the losses in the iron and in the copper at the corresponding induction. If we take, for instance, the case that the losses in copper and in iron are equal, the total loss in the transformer having an induction B = 5,000, is 2 × 309·6 watts. For the transformer having an induction B = 2,500, the loss in the iron is given in our curve 9, and the loss in the copper is in proportion to its weight, which varies in accordance with curve 8, or in this particular case, the loss is = $\sqrt{2} \times 309{\cdot}6$ watts. In this way curve 11 has been plotted for the case of the losses being equal, curve 10 represents the case where the loss in the copper is equal to two-thirds of the loss in the iron, and curve 12 where the loss in the copper is 50 per cent. greater than the loss in the iron. Taking these curves to represent generally the variation of the total loss at the various inductions, it appears that, when keeping the loss in copper small in comparison with the loss in iron, it is quite possible to obtain about the same efficiency with any induction between 2,000 and 5,000 lines per square centimetre, but if a lower induction is used the efficiency, even on full load, decreases very rapidly. From the consideration of efficiency it is, therefore, desirable to work the transformer with a high induction, and it is only the question of the heating of the apparatus which imposes restrictions on the use of high inductions, to avoid the destruction of the insulating material. In other words, the problem was to find the maximum internal temperature of a body of known dimensions, when the rate at which its mass is heated has been determined.

In order to obtain some data towards the solution of this problem, a solenoid was constructed by winding 18lb. of insulated iron wire, 2·4 mm. in diameter, on a brass tube 300 mm. long, 8 mm. internal diameter, and provided with flanges at the ends each 100 mm. diameter. The internal temperature was measured by means of a thermometer just fitting the brass tube, and due care was taken to keep the temperature of the surrounding air constant during the experiments. A constant direct current was sent through the coil, and a reading of the thermometer was taken after it had ceased rising. The rate at which energy was supplied to the coil was determined by the product of the square of the current into the resistance of the coil, measured when the equilibrium of temperature had been attained.

By varying the current the internal temperature could be varied, and the results were plotted in curve 13, the abscissæ of which represent the cooling surface in square centimetres per watt dissipated, and the ordinates indicate the excess of the internal temperature of the coil over the temperature of the surrounding air in degrees centigrade, after the equilibrium between the supply and the dissipation of energy had been established in each case. This curve is a rectangular hyperbola of the equation, $xy = 1{,}500$, and it shows that if the temperature of such a coil is to be kept at 100deg. C., the cooling surface should be 15 square centimetres for each watt converted into heat in the coil. It is self-evident that this curve (13) relates only to the coil by the aid of which it was constructed, and that it can only serve as a guide under strictly similar circumstances. By way of comparison a set of experiments were made on the same lines with a cable transformer, hung up in air, six metres long and 9·5 cm. in diameter, the internal temperature of which was determined by means of a test wire, as described above. This curve (14) shows that for an internal temperature of 100deg. C a cooling surface of about 28 square centimetres has to be provided per watt of energy converted into heat in the transformer.

Before it is possible to draw general conclusions as to the connection between the internal temperature of transformers and their cooling surface, it is obviously necessary to make a good many more experiments in the direction indicated by the two curves just described. Last year Dr. Fleming read a paper before this Institution on "Some Effects of Alternating-Current Flow in Circuits having Capacity and Self-Induction" (*Journal* of the Institution of Electrical Engineers, vol. xx., No. 94, p. 374). It is, therefore, not necessary to repeat here the results of some experiments which were brought to the notice of the Institution at that time. A very important factor in the construction of alternate-current apparatus is the striking distance of these currents in various materials, as this determines, in the case of high-voltage currents, the thickness of the insulating material with which the conductors have to be surrounded, the ohmic resistance being no guide. The first set of these experiments referred to the striking distance in air. In all the experiments made the frequency of the alternate current was 100 complete periods per second, except where another frequency is specially mentioned, and the voltage was produced by means of an alternate-current machine and a transformer, and it was measured by one of Sir William Thomson's static voltmeters. The electrodes were repolished each time a spark had passed between them; one of them was fixed horizontally during the experiments, while the other could be advanced towards it from above by means of a micrometer screw which allowed of reading to a hundredth of a millimetre.

The experiments were made in the following manner: After connecting the electrodes of the spark micrometer to the terminals of the transformer, a certain voltage was put on and accurately measured; the distance between the electrodes was then slowly diminished until sparking occurred. Each experiment was repeated at least three times. Various electrodes were experimented with, the first pair being two plane parallel surfaces. In this case the fixed horizontal electrode consisted of a polished brass disc about 100 mm. in diameter, while the movable electrode was also formed by a brass disc, but only 37 mm. in diameter. To prevent the action of sharp edges, the edges of the discs were rounded off. The temperature of the surrounding air during these experiments was 14·75deg. C. The results obtained are as follows:

Difference of potential.	Striking distance.	Difference of potential.	Striking distance.
2,000 volts	0·67 mm	10,000 volts	4·80 mm.
4,000 ,,	1·59 ,,	12,000 ,,	6·46 ,,
6,000 ,,	2·53 ,,	15,000 ,,	10·23 ,,
8,000 ,,	3·60 ,,		

The last reading, giving the striking distance for 15,000 volts, cannot be correct, as the sparks started from the upper edge of the smaller disc, and not from the nearest points between the two discs, the smaller disc being placed above the fixed one. Curve 15 is the graphic representation of the above table.

For the next series the arrangements were the same as before, with the exception that the smaller movable disc was replaced by a half-sphere of 10 mm. diameter. The temperature of the air during these experiments was from 16deg. to 17deg. C., and its humidity 80 per cent.

Difference of potential.	Striking distance.	Difference of potential.	Striking distance.
2,000 volts	0·45 mm.	10,000 volts	4·37 mm.
4,000 ,,	1·40 ,,	12,000 ,,	5·65 ,,
6,000 ,,	2·30 ,,	14,000 ,,	7·32 ,,
8,000 ,,	3·25 ,,	15,000 ,,	9·02 ,,

These results are plotted in curve 16.

After this the movable electrode of the spark micrometer was replaced by a steel point of an angle of 60deg., its section being an equilateral triangle of 5 mm. sides. This point was also repolished after each spark; the spark, however, did not always start from the point. During these experiments the temperature of the air was 12deg. C., and its humidity about 50 per cent.

Difference of potential.	Striking distance.	Difference of potential.	Striking distance.
2,000 volts	0·40 mm.	10,000 volts	5 78 mm.
4,000 ,,	1·26 ,,	12,000 ,,	7·60 ,,
6,000 ,,	2·66 ,,	14,000 ,,	9·37 ,,
8,000 ,,	4·08 ,,	15,000 ,,	10·70 ,,

Curve 17 embodies this table.

After this the influence of an alteration in the frequency was tried by lowering this to 80 complete periods per second, and repeating some of the first experiments with disc electrodes. The striking distances for 4,000 volts and for 6,000 volts under these circumstances were found to be 1·47 mm. and 2·30 mm., or only slightly different from those produced by a frequency of 100 complete periods per second. From theoretical considerations it

* Paper read before the Institution of Electrical Engineers, February 11, 1892.

might have been expected that the distances would vary directly as the frequencies.

In order to investigate the influence of capacity, one or more coils of guttapercha-covered wire were connected to the circuit of the transformer in parallel with the spark micrometer. The first experiments were made with a frequency of 100 complete periods per second, the two disc electrodes, and a capacity of 0·113 microfarad. The temperature of the air was 16·5deg. C., and its humidity 79 per cent.

Potential difference.	Sparking distance. With capacity.	Sparking distance. Without capacity.
4,000 volts	1·53 mm.	1·59 mm.
6,000 ,,	2·21 ,,	2·53 ,,
10,000 ,,	4·17 ,,	4·50 ,,

A further experiment under similar conditions, but with a capacity of 0 28 microfarad in circuit, showed that the sparking distance at 10,000 volts was further reduced to 3·94 mm. These tests were repeated with other electrodes—viz., the spherical surface and the disc. At a difference of potential of 10,000 volts the sparking distance turned out to be:

1. With 0·14 mf. capacity in circuit .... 4·08 mm.
2. Without any ,, ,, ... 4·50 ,,
3. With 0·14 mf. ,, ,, ... 4·06 ,,

After that the steel point and the disc were used as electrodes, a capacity of 0·14 mf. being connected to the circuit, and the results were:

Difference of potential.	Sparking distance. Without.	Sparking distance. With capacity.
4,000 volts	1·26 mm.	1·14 mm.
10,000 ,,	5·78 ,,	4·83 ,,

All these experiments point to the fact that the sparking distances in air are diminished to a slight extent when capacity comes into play. With a view of ascertaining how the voltage is propagated along a circuit, the position of the micrometer relatively to the cable was varied.

The experiments detailed above were made with the spark micrometer connected to the beginning of the cable; they were afterwards repeated after inserting the spark micrometer in the middle of the cable, and again after it had been connected to the end of the cable. In all three positions the same striking distance was observed under similar circumstances, which tends to prove that the voltage is propagated uniformly over the whole length of conductor, even if there is capacity in some parts of the circuit.

As stated above, the voltage experimented with was measured by means of Sir William Thomson's static voltmeters; but it is undoubtedly the highest ordinate of the wave which causes the spark. This "real" voltage can be found, if sine waves are assumed, by multiplying the measured volts by $\sqrt{2}$, and these new figures should be applicable to constant continuous currents. In this way the results of curve 15 were corrected, and compared with some results published by Warren de la Rue in *Nature* on the 12th September, 1878. Assuming that the E M.F. of his cells was equal to 1·03 volts, and reducing his results to volts and millimetres, they compare as follows:

Difference of potential.	Striking distance. Warren de la Rue.	Striking distance. Siemens.
2,000 volts	0·45 mm.	0·25 mm.
4,000 ,,	0·95 ,,	0·80 ,,
6,000 ,,	1·55 ,,	1·45 ,,
8,000 ,,	2·15 ,,	2·15 ,,
10,000 ,,	2 85 ,,	2 85 ,,

On referring to the other curves published at the same time, it will be seen that Warren de la Rue found the sparking distances between two plane surfaces and between two spherical surfaces not to differ very much from each other. It may, therefore, be allowable to compare the mean values of these two curves of his with curve 16 for the sparking distance between a hemisphere and a plane surface after the values of the volts have been multiplied with $\sqrt{2}$.

Difference of potential.	Striking distance. Warren de la Rue.	Striking distance. Siemens.
2,000 volts	0·36 mm.	0·25 mm.
4,000 ,,	0·87 ,,	0·80 ,,
6,000 ,,	1·50 ,,	1·45 ,,
[illegible] ,,	2·10 ,,	2·16 ,,
10,000 ,,	2·75 ,,	2·85 ,,

Both these tables show that the results are practically identical, and consequently it may be concluded that the secondary current of the transformer used for the experiments is really a sine function.

Some further experiments were made with the same alternate-current machine and transformer, and a frequency of 100 complete periods per second, to determine the striking distance in various insulating materials. The differences of potential were again measured by Sir William Thomson's static voltmeter, or, in the case of the higher ones, by his volt balance. One series of experiments, represented by curve 18, was made by connecting the terminals of the transformer to the inner and outer conductor of concentric cables, the insulation of which consisted of impregnated fibrous material. The difference of potential was then gradually and slowly raised until the insulation gave way. Curve 18 really consists of two parts, the lower of which was obtained by breaking 35 short samples of cable, made with various thicknesses of the insulating material; the upper part, above 7,000 volts, was determined by breaking actual cables, not less than 50 yards in length, specially manufactured for these experiments.

The next series of experiments dealt with indiarubber insulation, but results proved to be extremely irregular, although a curve (19) has been plotted which gives the minimum voltage at which sparking occurred at the various thicknesses.

The following table gives the details of the samples tested, and under what voltage they broke down:

No.		Thickness of indiarubber.		
1.	40in. of 880 H wire	3·5 mm.,	broke with	21,500 volts.
2.	10 yds. of experimental core,	3·8 mm.	,, ,,	20,000 ,,
3.	1½ ,, ,, ,,	2·5 mm.	,, ,,	16,000 ,,
4.	1 ,, concentric cable..	3·5 mm.	,, ,,	28,000 ,,
5.	90 ,, No. 504 core	1·2 mm.	,, ,,	12,000 ,,
6.	46 ,, ,, 505 ,,	2·0 mm.	,, ,,	16,500 ,,
7.	50 ,, ,, 507 ,,	1·8 mm.	,, ,,	18,200 ,,
8.	48 ,, ,, 508 ,,	2·3 mm.	,, ,,	16,800 ,,
9.	5 ,, ,, 200 H	2·3 mm.	,, ,,	28,000 ,,
10.	1 ,, concentric cable.	2·0 mm.	,, ,,	17,500 ,,
11.	Indiarubber sheet	0·5 mm.	,, ,,	7,500 ,,
12.	,, ,,	1·0 mm.	,, ,,	10,500 ,,
13.	Experimental piece of core	10·0 mm.	,, ,,	38,000 ,,

The concentric cables were tested by connecting the transformer to the two conductors; the sheets were placed between the disc and the spherical electrode. The core, when in short lengths, was covered with tinfoil; when long, it was immersed in water; and the terminals of the transformer were connected, the one to the insulated conductor, the other to the water or the tinfoil respectively.

Another set of tests were made by placing calico on the disc of the spark micrometer, and by connecting the other pole to a copper brush, such as are used in dynamo machines, resting on the calico. Several samples of calico were tried: (*a*) thin calico, 0·12 mm. thick, not impregnated; (*b*) silesia calico, 0·15 mm. thick, not impregnated; (*c*) thick calico, 0·30 mm. thick, not impregnated; (*d*) thick calico, 0·30 mm. thick, impregnated. All four samples required the same lowest difference of potential—about 700 volts—for a breakdown. Different spots of the same sheet behaved very differently, some not breaking with even 1,000 volts; but at least one spot could always be found which broke down with 700 volts. Curve 20 gives the results obtained with several layers of the impregnated thick calico. The layers were tightly pressed together before being tested, and the points of the curve give the minimum value of the voltage which broke them down. The last curve (21) records the sparking distance through celluloid, which was tested in sheets placed between the two discs of the spark micrometer.

A good many of the high-tension experiments were made with a specially constructed powerful transformer, capable of giving at its secondary terminals a current of two amperes under a pressure of about 50,000 volts. This is now on view at the Crystal Palace Electrical Exhibition, and various experiments are shown to exhibit its qualities. Unfortunately, it is too heavy to be shown in this Institution.

In conclusion, it should be mentioned that all the experiments described in this communication were carried out at Woolwich, at the works of Messrs. Siemens Bros. and Co., mostly under the immediate care of Dr. Baur, who was freely assisted by the heads of the various departments whenever he encountered difficulties in the course of his work.

CABLE-LAYING AT TANGIER.

"To the late Sir William Kirby Green we are indebted for the electric cable that now connects Tangier with Europe," says the *Times* correspondent at Tangier in an interesting article on Morocco, "and the history of the laying of this cable is amusingly characteristic of Moorish stolidity. Having obtained a concession for the cable, Sir William was determined to have the work commenced, but the Sultan was just as determined it should not be laid. He first tried the plan so successful with his own officers, and offered the British Minister a large sum of money if he would undertake to have the cable cut when laid and not allow it to be replaced. He was no doubt astonished when the bribe was contemptuously refused, and then his Majesty tried the plan of taking no notice of Sir William's letters requesting permission to commence the work. After sending several respectful communications, and receiving no reply, the British Minister gave notice to the Sultan that on a certain day the work of laying the cable would commence, and accordingly this was done. Of course it was very soon cut, but this was a last expiring effort of obstruction, for a duplicate shore end is now sunk deep in the sand, and the Moors, as usual, submit to the inevitable. At Tangier, however, electric communication ceases, and behind that outlying port lies a vast region dark as night. When Sir W. Kirby Green had successfully laid the electric cable, the Spaniards, wishing to show that they also could do something for Morocco, got up a company to light Tangier by electricity; and hence you have the strange anomaly of the Soko, or large open market, with its sea of ankle-deep black mud, lighted throughout the whole length of its rough-paved causeway by the electric light. Extremes meet in this place; but, of course, the company cannot pay, as there are no rates or other municipal blessings in Tangier, and the Moors are not likely to pay voluntarily for what they do not want."

UTILISATION OF WATER POWER IN MADRAS.

It appears that on completion of the Periyar project there will be available near Madras, at Kuruvanuth, an enormous amount of water power, aggregating in all some 180,000 h.p. The *Madras Mail* has recently called attention to this fact, and indicated the possibility of serving Madras with light and power from this source. After alluding to the experiments in transmission of power from Lauffen to Frankfort, and the proposed transmission from Niagara to Chicago, it says: "If we can obtain the power for producing the electricity from waterfalls, where the circumstances are favourable to the regular and continuous generation of power, and if the nature of the country be such that the works necessary to utilise the power can be constructed for a moderate amount, then the electric light can be produced at a cost with which no other illuminant can compete. Moreover, the same currents which produce the light, may, like gas, be used for heating purposes or for the production of power. From a central station, therefore, electricity might be made to flow all over the country, distributing heat, power, and light.

"To return to the power available at Kuruvanuth on the completion of the Periyar project. Of the 180,000 h.p. which can be obtained on the turbine shafts, 162,000 might be obtained in the form of an electric current of 3,000 amperes and 40,000 volts difference of potential. By using suitable conductors, at least 50 per cent. of this power might be made available at any point within a radius of 400 miles, and we might therefore deliver not less than 80,000 e.h.p. in Madras. Such an enormous amount of power could not be utilised here, and we might throw off branches from the main trunk line to the towns of Periyakulam, Kodai-kanal, Madura, Trichonopoly, Tanjore, Kumbakonam, Negapatam, Cuddalore, Pondicherry, and Chingleput. In all these towns, and in Madras itself, the whole of the street lighting, and as much private lighting as could be obtained, might be undertaken, and then there would be a sufficient amount of power still left to replace every steam engine in the districts through which the mains would pass with an electromotor. Electric lighting would, however, only be required during a small part of the 24 hours of each day, and during the rest of the time this vast amount of power might be used for an immense variety of purposes. In Madras we might have electric tramways. In many places lift irrigation by electrically-driven pumps might be economically introduced, and electro-metallurgy, a branch of engineering as yet in its infancy, would undoubtedly absorb all the power that could be spared.

"Naturally such great results could not be obtained without an enormous capital expenditure, such as in this country there is little hope of ever being undertaken without the assistance of Government. In America a company has been formed to develop 125,000 h.p. at the Falls of Niagara, and that company has appointed a commission of eminent engineers and scientists to consider the question of how to best generate the power and transmit it to the places where it is wanted. Here, in Madras, we have 180,000 h.p. available under nearly as favourable circumstances, and we think it would fall within the sphere of the operations of the Government of this Presidency to appoint a somewhat similar commission to report on the best methods of generating and making use of the vast amount of water power which it is possible to obtain in Southern India. During the last 35 years 24,000 lakhs of rupees have been expended, either directly by the Government of India or by private companies under its guarantee, in the construction of railways. This has been necessary, because they are works of public utility which could not well be constructed by unaided private enterprise, and on the same grounds and for the same reasons we think it is time that attention was drawn to the immense advantages to be derived by the country at large for the utilisation of the natural forces at our disposal. The vast beds of iron ore might be utilised for the cheap manufacture of high-class iron by means of the water power at disposal. This will probably offer the best field for the first attempts at the utilisation of water power on a large scale."

ELECTRO-HARMONIC SOCIETY.

The next concert will be a ladies' night, on Friday, March 4th, 1892, at the St James's Hall Restaurant (Banquet room), Regent-street, W., at eight o'clock. Artistes: Vocalists, Mrs. Alex. Siemens, Mr. Ed. C. de Segundo, and Mr. Thos. Harrison. Solo instrumentalists: Piano, Mr. Alfred Izard and Mr. Ed. C. de Segundo; violin, Mr. T. E. Gatehouse. Orchestra: First violins, Miss Edith Doughty, Mr. Hewlett, and Mr. T. E. Gatehouse (principal); second violins, Mr Dunn, Mr. Thornton, and Mr. S. Richardson (principal); viola, Mr. H. Gibson; violoncellos, Mr. Waite and Mr. Roger le duc Bucknall (principal); contra basso, Mr. Brewer; piano, Mr. Alfred Izard; Mustel organ, Mr. H. M. Higgs. Accompanists, Mr. Alexander Siemens and Mr. Alfred Izard. Musical directors, Mr. T. E. Gatehouse and Mr. Alfred Izard. A Broadwood piano will be used. The Mustel organ kindly lent by Messrs. Metzler.

PROGRAMME.—PART I.

Overture	"Mirella"	Gounod.
	Orchestra.	
Song	"Be Silent, Love"	Lawrence Kellie.
	Mr T. H. Harrison.	
Song	"Weep you no more, sad fountains"	Somervel.
	Mrs Alex Siemens.	
Selection	"Minuet" from Handel's "Berenice"	Arranged by T. Best.
	Orchestra.	
Song	"Du Fragst mich Taglich"	E. Helmund.
	Mr. Ed. C. de Segundo.	
Organ Solo	"Extempore"	
	Mr. H. M. Higgs.	
Song	"Mary of Argyle"	
	Mrs. Alex Siemens.	
Intermezzo	"Cavalleria Rusticana"	Mascagni.
	Orchestra.	

PART II.

Overture	"Poet and Peasant"	Suppé.
	Orchestra.	
Song	"Der Nussbaum"	Schumann.
	Mrs. Alex. Siemens.	
Piano and Violin	"Kreutzer Sonata"	Beethoven.
	Mr. A. Izard and Mr T. E. Gatehouse.	
Song	"Hungarian Love Song"	Roeckel
	Mr. T. H. Harrison.	
Piano Solo	"Polonaise"	Chopin.
	Mr. Ed C. de Segundo.	
Song	"Die Mainacht"	Brahms.
	Mrs. Alex. Siemens.	
Valse	"Arabian Nights"	Strauss.
	Orchestra.	

PHYSICAL SOCIETY.—Feb. 12, 1892.

Annual general meeting, Prof. W. E. Ayrton, F.R.S., president, in the chair.

The report of the council was read by the **President**, as was also the obituary notices of Prof. W. Weber, late hon. member, Mr W. G. Gregory, and Prof. James Crouch Adams. A list of additions to the library accompanied the report.

Dr. E. Atkinson read the treasurer's statement, showing a gain of about £140. On the motion of the **President** the reports of the council and of the treasurer were unanimously adopted.

Prof. Van der Waals was elected an hon. member of the society.

Prof. Reinold proposed a cordial vote of thanks to the Lords of the Committee of Council on Education for the use of the rooms and apparatus in the Royal College of Science. This was seconded by **Prof. S. P. Thompson** and carried unanimously. A similar vote was accorded to the auditors, Dr. Fison and Mr. H. W. Elder, on the motion of **Mr. W. Baily**, seconded by **Dr C. V. Burton**.

The following gentlemen were declared duly elected to form the new council:—President: Prof. G. F. Fitzgerald, M.A., F.R.S. Vice-presidents: Prof. A. W. Rücker, M.A., F.R.S., Walter Baily, M.A., Prof. O. J. Lodge, D.Sc., F.R.S., Prof. S. P. Thompson, D.Sc., F.R.S. Secretaries: Prof. J. Perry, D.Sc., F.R.S., 31, Brunswick-square, W.C., and T. H. Blakesley, M.A., M.I.C.E., Royal Naval College, Greenwich. Treasurer: Dr. E. Atkinson, Portesbery Hill, Camberley, Surrey. Demonstrator: C. Vernon Boys, F.R.S., Physical Laboratory, South Kensington. Other members of council: Shelford Bidwell, M.A., LL.B., F.R.S., W. E. Sumpner, D.Sc., Major General E. R. Festing, R.E., F.R.S., J. Swinburne, Prof. J. V. Jones, M.A., Rev. F. J. Smith, M.A., Prof. W. Stroud, D.Sc., L. Fletcher, M.A., F.R.S., G. M. Whipple, D.Sc., James Wimshurst.

A vote of thanks to the officers of the society was proposed by **Mr. Swinburne**, seconded by **Mr. A. P. Trotter**, and carried unanimously.

The **Chairman** then invited suggestions towards improving the working of the society.

In response, **Prof. S. P. Thompson** said that as the society had been established 15 or 16 years, and had amply justified its existence, the time had now arrived for giving fuller recognition to the privileges of members. He thought they had earned the right to be called "Fellows," and that this ought to be signified by some distinctive title.

Mr. J. Swinburne suggested that before papers were brought before the meetings they should be read by a member of the council. If suitable, they should then be printed and proofs sent to members who applied for them. Mathematical papers could then be taken as read, and the discussions would be more interesting and to the point. It would also be an advantage if communications on kindred subjects could be taken the same day and discussed together. Papers on purely technical subjects should go to the technical societies.

Prof. Ayrton, in reply to Mr. Swinburne, said the members had the matter of papers in their own hands, for, as pointed out in the report of the council, if they would only send in the papers early enough, the secretaries would be glad to group them in the way suggested. Referring to Prof. Thompson's remarks, he said he had often thought it would be an advantage to have another class of members in the shape of "students," who should hold meetings amongst themselves.

Mr. A. P. Trotter said the society was unique in many respects, and thought it was not desirable to have different grades of membership.

Dr. C. V. Burton agreed with Mr. Trotter, and said that even if Prof. Thompson's suggestion was adopted means should be provided that persons could be admitted into the society without claiming any distinction therefrom.

Prof. S. P. Thompson, referring to the communications brought before the society, said it was not necessary that all should possess great novelty. Descriptions of new arrangements of apparatus, of diagrams, and exhibits of modern instruments were of great interest to members.

The **Chairman** pointed out that at the early meetings of the society exhibitions of instruments were frequent, and said the council would be glad if instrument makers would send apparatus to be shown at any of the meetings.

The meeting was resolved into an ordinary science meeting, and Messrs. W. R. Bower and E. Edsen were elected members; after which Prof. S. P. Thompson, F R.S., communicated a "**Note on Supplementary Colours.**"

THE NATIONAL TELEPHONE SERVICE.

The London Chamber of Commerce held a special general meeting on Monday at Botolph House, Eastcheap, to consider the state of the telephone service in the metropolis and elsewhere. Sir Albert Rollit, M.P., chairman of the council, presided.

The **Chairman**, in opening the meeting, said that despatch was an essential element of modern business; the saving in time being not only often the source of profit, but a chief means of cheapening production and distribution. The perfection of communication was of the greatest advantage to commercial classes, and it was clearly to their interest to carefully watch the telephone Bills now before Parliament. They should consider whether the fullest development had been given under existing conditions, and whether other nations obtained greater facilities, as his experience led him to believe. In America, for instance, long trunk lines are in general use; in France he had had the opportunity of speaking from Paris to Marseilles, and no communication could be clearer. If it be the fact that England is behindhand, we must seriously bethink ourselves of the cause. In steam and other engineering we have long been in advance of other nations, and we ought at least to be equal in telephone facilities to other countries. As to cost, there seemed room for a very considerable improvement. With regard to induction noises, no very great improvement over the original instrument was desirable, he thought; he had in his possession the second pair of telephones ever brought into this country, presented by his friend Prof. Graham Bell, and their enunciation was as good as any he had heard. He did not think that the difficulty with induction would be got over until a more general use was made of a second or return wire. This was a real necessity—it might add to the cost, but efficiency was the first consideration. Then there was the internal management of the operating staff—experience had shown abundantly that it was bad; latterly there had been some improvement, and persons' tempers had not been tried quite so much. With regard to the Bills before Parliament, the question was whether compulsory powers were to be given to private trading companies, or whether they should be exclusively under the Government State Departments. Experience with the Post Office had led one to conclude that wherever Government could be trusted to supply as good a service as private companies, there was a great advantage in so doing. If we could believe that the telephone service could be conducted in a thoroughly efficient manner, and not, as was the case in the Post Office, make the service primarily a source of revenue to the country, but to devote the profit to increase of efficiency, the performance of this duty should be undertaken by Government. An efficient telephone service was not only important directly in cheapening the cost of production, but indirectly in many branches of business. Electrical engineering was a branch which had by no means reached its limits; many industries were now dependent on electricity, and it should be noted that electrical work was now the most progressive branch of science in this country—it underlies every other trade. It is important the public should be educated and given the greatest improvements. This was to be done by technical education, but education would be of little use for persons working in the shops if one could not continually see progress in professional work. It was important to England, in this age of competition, to maintain itself at the head of the mechanical and scientific arts.

Mr. F. W. Reynolds moved a resolution, to the effect that the Chamber should appoint a deputation to apply for an interview with the Postmaster-General, and express the views of the Chamber as to the supreme importance of the Government bringing a Bill into Parliament dealing with the question of providing adequate facilities for telephonic development throughout the country. It was of extreme importance, he said, to use all the facilities possible at the present time, when we were severely handicapped in all the markets of the world. In many cases, also, it was not a question merely of cost but of quick despatch, as in cases which came before his own notice. Personally his experience with the telephone was good—his was a private line—but he heard constant complaints from his friends and customers.

The motion was seconded by **Mr. J. Martin**.

Mr. Jackson asked as to the scope of the Bills before Parliament.

Sir Albert Rollit read out the headings of the National Telephone Company's Bill: To open or run over any public road, erect posts, open or alter pipes, run lines over sewers or estuaries, place and repair posts on private grounds with compensation to owner, items as to compensation for ground taken, consent of local authorities, restitution of roads, restrictions as to impeding traffic, powers for stringing wires over private property, and so forth. The New Telephone Company's Bill was for powers to enter into and contract with authorities for running lines in, under, or over every street or railway, etc., and was more permissive and contractual in its character.

Mr. J. Chambers said he failed to see the object of appealing to the Postmaster-General. The two large companies had put their claims before the Chamber, and he considered the commercial world would be better served by private enterprise. He moved an amendment expressing an opinion that an efficient telephone service could not be given to the metropolis unless statutory powers were given to the companies.

Mr. Faithfull Begg seconded the amendment. The question resolved itself into whether the national telephone service should be carried out by the Post Office or by private enterprise. He could quite believe the time would come when the telephone service of the kingdom should be controlled by Government, but at present he believed it far better to leave it in the hands of private companies. Present evidence showed that, in spite of the fact that the Post Office had established telephone exchanges, they were left without any exchange of importance (excepting, perhaps, Newcastle, though he did not acknowledge this as really important) in the country, and not only so, but it has been beaten by private enterprise out of several towns. The fact was the genius of the Department was not able to deal with the exigencies, and it was not reasonable to leave it to the Postmaster to develop the industry. The National Telephone Company, he said, "had always carried economy on its banners"; it had commenced in the provinces, and had rapidly reduced the tariff to £10, with the exception of the metropolis, where the difficulties were so great—there was no other part of the civilised world where so many difficulties could be encountered. He agreed the powers should be hedged round, but if powers were granted to the electric lighting industry, why not to the telephone? He recommended the deputation to go straight to Government and press for powers for the private companies.

The **Duke of Marlborough** said that the question was one of enormous importance to the community at large. Very few really recognised yet what telephony actually was. We were accustomed to send down to the post office and send off our telegrams, or to ring up subscribers in our own town. But from Land's End to John O'Groats, any firm of importance, any subscriber to the ideal system, should be able to speak at once and in a few moments to any other person, be he in Birmingham, Glasgow, or Manchester, as one might speak into the next room. That is what telephony meant! He wished to put before the council this consideration—that they were members of the Empire and taxpayers, and, therefore, the real owners of the telegraph monopoly. If they allowed the telephone to cut out the telegraph—as it undoubtedly would eventually—what was going to happen? Did they wish to lose the immense sums of money invested in their telegraph service? This must be guarded against. The Post Office had natural possession of the underground lines, and had no need of extra facilities. He would suggest that the inter-town trunk lines should be in the hands of the Post Office. No Bill could give power to a private company as comprehensive as the Post Office already possessed, and it was the duty of the taxpayers to keep these powers in their hands. No doubt the Postmaster has put obstruction in the way year after year, but he thought he should be revealing no parliamentary confidence in saying that he knew that it was the intention of the Postmaster-General to bring in a Bill of his own. What the terms were he did not know further than that it would be a Government Bill to give facilities for underground telephone wires. Also, both the private Bills were to be opposed. He thought it would be unfortunate if these Bills were opposed before the second reading, as it would be to the interest of the public that evidence should be called in Committee, and it might be advisable for the Chamber to bring their influence to bear and secure this. He thought the laying and management of the telephone trunk lines should be in the hands of Government. As regarded distribution of the telephone messages, he thought this part might be left in the hands of private companies—if Government took over the trunk mains, and private companies did the actual exchange work, this he thought would prove the best for both taxpayers and private individuals. Parliament would never allow private companies to have general powers over the country—it was against all precedent and the feeling of Parliament. The electric lighting companies had no general powers of this kind, but were under one general Act vested in the Board of Trade. As regards tariff, no doubt £20 was too much; £12 would be sufficient, and this would allow a complete system of twin wires, which are absolutely necessary if a perfect system is to be secured. Further, a great difference must be made in the operating staff arrangements. With the present system in force in London many persons would sooner not speak at all. It should be perfectly possible to speak to six or seven persons in as many minutes. Still, bad as the present system was, it was extremely useful, and he recently had the instance of a patent agent who avowed the telephone was worth £1,200 a year to his business. He urged the importance of the first resolution that a definite expression of opinion should be obtained from the Postmaster-General, whether the Government is going to give powers to private companies is to bring in a Bill affording general powers.

Colonel Raynsford Jackson, chairman of the National Telephone Company, said that what his company wished to see was the granting of statutory powers under which the telephone companies

could do their work. They do not ask for special powers for themselves—the powers accorded to one should be accorded to all. The great difficulty in their way was that of way-leaves. The reason that the telephone was cheaper in other countries was simply that it could be worked cheaper. He had recently seen Berlin exchange, where they had 17,000 subscribers, while London only had half that number. The exchange there is in the hands of the Government, and no way-leaves are required. There are five exchanges with connections for 6,000 each, and about 3,500 are connected. The wires are run as the crow flies, and there are no royalties to pay. In England they are saddled with a 10 per cent. royalty; where a mile of wire would be sufficient they had to run 1½ miles. It cost them 30s. per subscriber for way-leaves, and the royalty came to £2 per subscriber, besides which they often had to encounter great cost in moving the wires to circuitous routes if way-leaves were not accorded or were stopped. They might reduce the subscription in London, but if they did, they would be unable to cope with the increased demand from difficulty with way-leaves, and they preferred to continue the high tariff—they simply could not connect up the additional wires. Reduction of tariff could only come about by accordance of fuller powers. They had now 22 exchanges scattered over a large area. These they have connected with twin wires, which lessens the sound. But it was only in last January, after two years' work, they had succeeded in connecting an adequate number of wires. The company recognised as well as anyone that metallic circuits are necessary, but could not obtain the facilities. They had long applied to the Commissioners of Sewers to allow them to put pipes underground, but had been refused. This would have enabled them to give twin wires at least to all the City subscribers, which embrace two-thirds of the whole number connected—a long way towards the complete metallic circuit. As soon as they received powers that was the work they would at once undertake. Even now they had done what they could, and Croydon, Sydenham, and part of Kensington has metallic circuits. It is not because they do not choose, but because they could not—they did the best they could under the circumstances. Still, as to the single wire, he would point out that it does its work excellently in many cases. All the exchanges in Austria, except that of Vienna, are on single wires; in Vienna they have double wires, because the Government has insisted on the wires being placed underground, and for underground service twin wires are a necessity. In France it is the same—all exchanges are on the single-wire system, except Paris, where wires are run in the sewers. With reference to the question of public or private enterprise, an example of the course of events was to be taken from Leicester, where the Post Office had 133 subscribers; when the National Company opened, the Post Office subscribers fell to 100 and the National had 275. In Hull they had more subscribers than the Post Office exchange, though it had been opened for 10 years. So far the single-wire system had shown itself adapted for places where one exchange was sufficient, where the wires are not of great lengths, and where they are not required to go underground. As to trunk mains, the National Company had now 20,000 miles of trunk mains over which they sent 1,600 millions of messages a year, at a cost of less than 1d. each. When it is advised that the trunk mains should be taken over by the Government it could be seen that such a proposal was of immense importance to the company, who, having taken the trouble, wished to reap the advantage. They would not agree to the taking over of the trunk mains alone—they would even rather the whole were taken.

Mr. Provand, M.P., chairman of the Mutual Telephone Company, said the Mutual exchange was opened in Manchester last February with a list of 100 subscribers. They had now 1,000 on the list, while the National Telephone Company had only 1,600—that is, in a few months they had obtained two-thirds as many subscribers as the National Company had obtained in 10 years. This was due to the better service and the lesser rates. The National tariff was £20, the Mutual tariff was £5 to shareholders (of whom there are 630), and £6 to non-shareholders. They had as many as 1,400 on their list, of whom 930 or nearly 1,000 were actually connected. When it was stated that the National Company kept the word economy on their banner it must have been in laying out money, not in tariff, that was meant. When Colonel Jackson had explained the high tariff as due to difficulties with way-leaves he must have been perfectly aware that there was another difficulty, far more important, which he had thought well to conceal, this was that the National Telephone Company had a very small amount of cash and an enormously large sum of paper capital. The work was done in London as bad as it could possibly be done. There was not a man on the Board of the old company that knew his business, and though the old company passed away there were still some of the old members on the present Board, and there was no one who could or would deal with the schemes from the use of the people. There were several very cogent reasons why the company could never be successful—the financial question was the principal one, and the other was that of twin wires. Notwithstanding what Colonel Jackson had said, there never would be a successful telephone service until twin wires were adopted throughout. Some towns might have a fairly serviceable system, but if any person wished to compare the two they could not do better than go to Manchester, where the two were working side by side. He would be glad to show deputations and let them test both the Mutual and the National, for he had them both in his office, and he did not hesitate to say which they would find by far the best.

Mr. Sheriff Foster, as a subscriber, said he hoped a better service would be the outcome of the meeting. He trusted that the National Telephone Company would not be allowed to absorb the new telephone company spoken of by the Duke of Marlborough. The way in which London subscribers were served was admitted by Colonel Jackson even to be very inefficient. They received the very minimum of service for the very maximum of cost.

Mr. Sydney Morse urged that Parliament should allow the Bills to go into Committee as suggested by the Duke of Marlborough. He thought restrictions should be enforced to prevent exorbitant tariffs being levied, and that conditions should be inserted to prevent the telephone companies laying further claim (as they did now) to a monopoly of the earth as a return. He suggested the two resolutions should be amalgamated.

The **Chairman** said that this was exactly what he was intending to propose.

The resolution as amended was then passed unanimously as follows:

"That, in view of the importance of the telephone industry, and the fact that two separate companies have Bills before Parliament, this Chamber should appoint a deputation to apply for an interview with the Postmaster-General, and express the views of the Chamber as to the supreme importance of her Majesty's Government bringing a General Powers Bill into Parliament, so as to afford facilities for the development of the telephone not only in the metropolis, but also with regard to inter-town service all over the country, whether by private companies or by the Government itself."

The following names were handed in to be submitted to the council of the Chamber of Commerce as a deputation: Sir Albert Rollit, M.P., the Duke of Marlborough, Mr. Provand, M.P., Mr. F. W. Reynolds, Mr. Chambers, Mr. Bennett, Colonel Jackson, Mr. Faithfull Begg, Mr. Jackson, Mr. Sheriff Foster, and Mr. Sydney Morse.

In the course of the meeting Mr. Wallace announced that the recently formed Association of Telephone Users would be registered as a public body with members at 5s. a year, having thus a *locus standi* in all questions of Bills before Parliament, and he urged members and subscribers to join this association.

COMPANIES' MEETINGS.

WESTMINSTER ELECTRIC SUPPLY CORPORATION.

The ordinary general meeting of the shareholders of this Company was held at the Westminster Palace Hotel on Wednesday, Lord Suffield, chairman, presiding.

The **Secretary**, Mr. Frank Iago, having read the notice convening the meeting,

The **Chairman** then said that he was not yet sufficiently recovered from a severe illness to address them, but perhaps they would allow him to move the adoption of the report and accounts in a formal manner. He would ask his friend Mr. Powell to do his (the Chairman's) duty for him on this occasion.

Mr. J. H. Powell, before proceeding to make any remarks on the report and accounts, expressed the wishes of the Board and of all the shareholders present that the Chairman might be restored to health. They had been greatly pained by the news of his long-continued illness, and hoped now that he had come among them again he might become as strong as ever he had been. The report having been taken as read, the speaker continued: We have now the pleasure of congratulating you upon the possession of three central stations, one in Millbank-street, which is practically complete—in fact, I don't think that any more payments will have to be made with regard to it, except for some condensing apparatus. Then we have a central station at Eccleston-place, which, so far as plant and works are concerned, is almost complete. And then we have, further, the station at Davies-street, which is in an almost similar state. At Eccleston-place we are making provision for offices for the Company, offices for the secretary, for the engineer and his assistants, and a Board-room. The erection of these buildings will be completed for an amount the interest upon which will be very considerably less than the rental we are paying for somewhat inconvenient premises in Victoria-street. At Davies-street we are covering the frontage with flats or chambers erected at no very large cost, and we expect a very considerable rental from them. The buildings have all been put up in the most substantial way, and I hope any shareholders who have the opportunity will go and see for themselves how we have combined the very best construction, without being at all extravagant. I think you will all say if you see these buildings that they are an ornament to the neighbourhood in which they are, and I believe they will be surrounded by buildings of a similar character. The greatest care has been taken by our engineer to put up machinery of the best description, at the least possible cost, and which, moreover, I believe to be the most economical. But we have arrived at this result after a great many drawbacks. In the first place, our architect tells me that we were delayed at least 66 days by the severe frost of 1891; and, moreover, the carpenters' strike of that year delayed the Davies-street buildings at least six months. Yet, notwithstanding these great drawbacks, the promise which we held out to you at our last general meeting that we should be able to work from Eccleston-place within about a fortnight, was fulfilled almost to the letter. Within a week of our meeting we were able to start Eccleston-place—that is, by the 2nd March—and on the 4th March we were able to supply light for her Majesty's Drawing-room with as much perfection, I believe, as characterises any of our lighting. Then I must tell you that at the end of February of last year we had only 13,148 lamps on circuit, and to show how the electric current was wanted, we

found that in March there was an increase of 5,842 lamps; in April, 9,992; in May, 6,789; in round numbers about 22,000 lamps. That is, an *increase* of 22,000 lamps over and above the small number we were supplying at the end of February, which was only 13,148. Then by the end of June we were supplying about 37,000 lamps; that was, in round numbers, about three times what we had been supplying in February. But when June came sunlight was beginning to take the place of electricity. People were beginning to leave town residences, and, notwithstanding the great increase in our lamps, we found that our revenue did not increase in a like proportion. However, the increase of lamps still went on. In June we had an increase of 1,500 odd, in July 2,700 odd, August 2,500, and then as the days got shorter the increase became larger still—4,900 (Sept.). Altogether in these four months we made an increase of 11,692 lamps, which I think was very gratifying under the circumstances. We found, however, that there was no increase of revenue. The light of the sun kept on and people kept away, and it was not until October that we began to realise the great increase that we had made in our business; while it was not until December that we found that fog was our best friend, as I believe it always will prove to be. Towards the end of December our receipts in one week rose from £800 to £1,200—that is, an increase of 50 per cent. Of course this put a very heavy strain upon our engineer, and all who worked under him, and I am happy to say that the supply in that week was as good as it had ever been. It is still more gratifying for me to say, that when the following week came and the receipts for light at once fell down from £1,200 to their normal state of £800, the expenses seemed to decrease almost automatically. The figures I have given you will explain why the income we show on Dec. 31 is so small—viz., because during the first part of the year we had comparatively few lights, and it was only as the season went on that the great increase took place. Again, it was only in November and December we showed what a valuable business we had. It will be interesting for you to know what is likely to be our income from our present circuit of lamps. I take our present number at the very low figure of 68,000. I may tell you that since December 31 the number of lamps lighted has very largely increased, and that we have now arrived at the figure of 75,253. But I will take the very moderate number of 68,000, and the still more moderate estimate of 10s. per lamp and that will show you that we should have an annual income of £34,000, instead of the comparatively small income which is shown in our published accounts. These accounts give our income as £19,000, so that upon a lamp circuit of 68,000, we shall have an increase in revenue of £15,000. But then, of course, these figures are very far within the mark. We find now that the increase in applications for light per month amounts to something like 4,000 lamps, and we see no reason why this figure should be less, although we can hardly expect that we shall gain the enormous increases this year that were shown during the past year. I am quite satisfied of this: if we supply a good light at a moderate price people will see that electric lighting has become one of the necessities of the age; that it is necessary for people's comfort in their houses, and also most necessary for the conduct of business. In my own very small experience I have occasionally to go to hotels, and I always choose those which have the electric light. I find that it is the best light, that it gives the least unpleasant heat and no unpleasant fumes, and I take it that every hotel and every clubhouse will within a very short time be obliged to avail themselves of the light which we offer them. Now I must again recall to your minds the very great disadvantages under which we have laid during the past year. Anyone who had gone to Davies-street station about this time last year would have said that it was utterly impossible that we could have supplied electric light from that station for several months. Everything was in the greatest confusion. We had an enormous number of excavators, builders, bricklayers and labourers at work, and you know, from your own experience in private houses, the dust these gentlemen make about them, and how destructive that dust is to machinery. Notwithstanding this, when we saw the business that was offered us (the very large business shown in our monthly increases) we thought it was wise in your interests to put up a temporary building and to work this business at any reasonable cost. The cost, I confess, was great, but I think that the advantages are far out of proportion to the cost of producing the light. Having so far descanted upon what has taken place, and what are your probable requirements, it may naturally occur to many of you to ask me, "What provision have you made for the future?" I think I can tell you tolerably accurately. We are supplying about 68,000 lamps from our present premises, and we find that with our existing machinery, either in place or on order, we have accommodation for about 130,000 lamps. If the space at our disposal within the existing buildings were utilised, we could supply from Millbank-street 30,000 more lamps, Eccleston-place 60,000 more lamps, and Davies-street 75,000 more lamps, so that altogether the existing premises could supply 165,000 more lamps. That brings up our capability of supply to 295,000 lamps which I will take to be, in round numbers, about four times our present output; but that is not the measure of what we can do. We find that at Eccleston-place we have a very considerable space in addition, so that when the time comes we shall be able to enlarge our buildings there, and to some extent at Millbank-street also, so as to arrive at a still larger increase—altogether, with our extra space, we shall be able to supply about double the figure that I have mentioned (295,000). This is, I think, very satisfactory. I may tell you, in passing, that at Eccleston-place we shall probably have to put up a little more machinery to accommodate the extra number of lamps, and I think it is not unlikely that we shall have to work that station tolerably hard when we get to the end of our tether; because I take it that the time must come, if Mayfair goes on as it has already begun, when we shall have to provide further accommodation in that district. I won't go on with these observations any further, but I will take you to something which is more immediately pressing, and that is the amount which we shall have to allow for depreciation of machinery. You will see that in these accounts we have allowed £1,000, which we consider to be both fair and ample. Our machinery is new, and a great deal of it was not thoroughly worked until towards the end of the year, and therefore, although everything wears as soon as it is put into work, we ourselves among the number, yet we thought it was only right that we should put a certain sum against depreciation of machinery. But I must not deceive you by letting you suppose that £1,000 will in any way be sufficient for the depreciation which we are likely to set against our revenue, and upon this matter I will quote a report of our engineer, which I believe you may thoroughly rely on. He says: "I think it would be wise not to allow less than £100 a week to be set apart for depreciation, paying all maintenance charges out of revenue, in order that the Corporation may be able to meet the possibility of some new invention or improvement being so rapidly matured as to make some of our machinery obsolete." In passing, I may say that our machinery is of the best and newest description, but electric lighting being a new invention there is no knowing what developments may take place, and so I quite agree with our engineer. I ought not to say that I agree with him because I am no one and he is everybody, but I thoroughly confirm all that he says in this matter. The speaker then continued his reading of the engineer's report, as follows: "So far as we at present know there is no astounding economy to be made in the cost of production of electric light. Economies in detail will, of course, be effected, and the cost of production will be reduced as the total output increases. But any economies at present must be the straightforward results of thorough good management and unremitting attention to details. If some happy inventor succeeds in showing us how to provide light by electricity without producing heat, there will be an enormous saving at once. Many inventors have been at work at this for a long time, but as yet they have not attained any results, so far as I know, of any commercial importance. No one can deny that within a reasonable number of years some such discovery may be made, although at present the very best work that has been done does not seem to have pointed out to us the right path. It is right to remember, however, that steam boilers, engines, mains, dynamos, etc., will be required whatever system may be the system of the future, and although in all probability dynamos different from those at present in use will be required, the rest of the plant may quite possibly remain unaltered. In any case, the change of dynamos would be common to every supply company, and not peculiar to one, so that we should be still in quite as good a position as any company." These figures, £100 a week, have not been adopted by the Board, but I may say that we have such very great confidence in Prof. Kennedy's figures, that I do not doubt we shall see the wisdom of adopting them and the policy which he recommends. The tax on the energies of the Board during the construction of the works has been very heavy, and it is no small credit to those who started this Company—of whom I was not one—that they so accurately calculated the requirements of the districts. They said that it would require £300,000 to start this business, and we have managed to keep within that mark for the districts that were allotted to us. But I should not be doing my duty if I were to claim for myself, and I am sure my colleagues would not wish for a moment to take credit to the Board for the results that I have put before you—they are mainly produced by the foresight, the constructive power, and the unfailing energy of our superintendent engineer (Prof. Kennedy). It would be wrong of me to attempt to take credit for anything of this kind, unless I put his name prominently before you. He has always kept his work well within his estimates. Not only have I been struck by his accuracy in figures and his power of design, but also by his readiness to take advantage of every appliance which has been invented to reduce the cost of working, and I should say that no company has carried out similar works at a less cost or with greater success. I believe that no company within two years of its active existence has been able to supply the public with so many lights, or so well, and for that result you should in a great measure thank Prof. Kennedy. I must also single out your architect (Mr. C. S. Peach) for much praise. He has evidently entered into the spirit which has throughout animated the Board. He has worked well and cordially with Prof. Kennedy, and in every dispute that we have had—and people carrying on large buildings cannot avoid disputes—with adjoining owners, he has not only kept us free from litigation, but with the help of the common sense he always carries about with him has succeeded in making good settlements for us. I must also say words of praise in favour of Captain Bax and our whole staff. Captain Bax has been most successful in getting customers and dealing with them after we had obtained them, and now that our business is likely to be one more concerning administration than construction, I believe that he will cordially work with us and will be a great helping hand towards carrying out the policy which Prof. Kennedy has put forth in the report which I have read to you. (He then pointed out a diagram on the wall, on which different coloured lines represented the number of lamps installed, the amount of revenue, and cost of production, pointing out that the line representing revenue bore out what he had said—viz., how during the summer months the revenue ran down and the expenses were slowly climbing up, but how matters were righted when the short days and fogs came on.) Continuing, the speaker

said: I have only one or two remarks to make on this chiefly in answer to a shareholder who has written to the Secretary, and who wished me to answer the question at the meeting. The question was, "How is it that our cost of generating electricity appears to be so high in comparison with the cost of another company?" The reason is that that other company began with a good business at the beginning of 1891, and that we, as you will see from that diagram, had hardly any business at all. But during the whole of the year we were obliged to have an engineering staff to do the small business, and it was not until we had reached September or October that we actually paid our working expenses. It could not be otherwise. We had three stations, we had three resident engineers, and a number of people about us that we could not possibly discharge—in fact, we could not carry on the business without them—and therefore the cost of generating the electricity appears to be comparatively high. But if you will go into details I think you will find that our cost is quite as low as the other company's, and that the explanation I have given you is ample for the purpose. I will conclude my remarks by seconding the adoption of the report, and beg to say that if any gentleman here requires any explanation of the accounts or the report, my colleagues and I will be most happy to give it.

A question put by **Mr. Wm. Cooper** as to the issue of £30,000 in debentures having been answered and proved to rest on a misapprehension, due to absence abroad,

Mr. Fitch, the writer of the letter alluded to by the Deputy-Chairman, said that he drew attention particularly to the coal expenditure, which was proportionately £700 more than another company. He also alluded to the cost of oil, waste, and water, which was between £300 and £400 more than in the other company.

Prof. Kennedy, at the request of the Chairman, answered this question. He said that at the time of year when they were working by no means economically—viz., at the beginning of the year—they had a temporary station at Davies-street, which was using 50 per cent. more coal per unit than was used now. When they were first started, the stations at Davies-street and Eccleston-place were using more coal proportionately than was the case now. The questioner was comparing the work of the Company with 10,000 lamps going in January, with the work of a company beginning with 30,000 lamps at the same time. He had been through the accounts very carefully, and the cost in pence for the last two quarters, when they had had a considerable number of lights on, had been precisely that of the company alluded to by Mr. Fitch, and the total sum paid by them and by the Westminster Company per unit was about the same. The cost of stores, water, and oil was a little less with the Westminster than with the other company. He trusted that next year they would be the most economical of all the companies. There was no fair comparison between a year in which they had been working upwards under difficulties, like last year, and a year such as they were now beginning with a fairly full load on.

The **Chairman** then put the motion adopting the report and accounts, and it was carried unanimously.

A **Shareholder** asked as to the prospect of a dividend.

Mr. Powell said they had not discussed the matter. They dealt with facts and not with prophecies, and would rather wait and see the result of the next six months' working. As soon as it was possible to declare a dividend they would do so.

The **Chairman** concurred, remarking that he thought the honourable proprietor would see that they were in a fair way to success.

Mr. Reed proposed the re-election of Messrs. Cooper Bros. and Co. as auditors. This was duly seconded, and carried.

Prof. Kennedy invited shareholders to go over the Company's stations, as he was sure they would be interested in what they saw there.

A vote of thanks to the Chairman for presiding under exceptional difficulties, and to the Board, was heartily accorded on the proposition of **Mr. Mark Stewart, M.P.**, seconded by **Mr. Cooper**, and the proceedings closed.

BIRMINGHAM ELECTRIC SUPPLY COMPANY.

The second annual meeting of this Company was held on Thursday week at the offices of Company. Mr. H. Buckley presided.

The **Chairman**, in moving the adoption of the report (see *E.E.* for February 12th), said the close of the financial year was altered from the 31st March to the 31st December to meet the requirements of the Board of Trade. The accounts showed a profit of £713. 16s. 4d.; but although the number of lights on the 31st December was 5,480, that was not the number of lamps earning an income during the nine months. The average number of lamps was 3,135, or, in other words, the earning power of the 5,480 lamps was only for 5·15 months. They commenced in April with 795 lamps only, but that number increased to 5,192 lamps earning an income, although there were 5,480 on order. At the present time there were more than 6,100 lamps on order. The current had been taken by various classes of the community, including hotels, clubs, public buildings, institutions, restaurants, shops, banks, insurance offices, general offices, and a theatre. The demand for the light had been most satisfactory, and during the coming year it would be necessary to extend their mains and make some increase in their engines and dynamos in order to be prepared for an extension of their business, and to meet any temporary difficulty which might occur through their plant getting out of repair.

Mr. C. A. Harrison seconded the resolution, which was carried.

Messrs. J. F. Albright and G. H. Johnstone were re-elected directors, and Messrs. Sharp, Parsons, and Co. auditors.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY.

The twenty-eighth ordinary general meeting of this Company was held at Cannon-street Hotel on Tuesday, Mr. S. William Silver, chairman, presiding.

The **Secretary**, Mr. Wm. J. Tyler, having read the notice convening the meeting,

The **Chairman** moved the adoption of the report and accounts, together with the declaration of a dividend and bonus for the year at the rate of 12½ per cent. The amount carried forward was, he said, £42,073, after adding £25,000 to reserve. He wished to impress upon shareholders the fact that the amount of their share capital was very small when they considered the nature and extent of their business. By looking at the accounts (*vide* last issue of the *Electrical Engineer*) they would see that the first item of their "assets and expenditure" was £70,000 more than the whole of their subscribed share capital, and yet some shareholders did not see the advantage of their reserve fund. But it was necessary. In fact, the working capital, with the reserve added, was too small to enable them to undertake extensive contracts when offered. They must remember that cable contracts were generally large ones; and when two or three came to be open for tender about the same time, contractors needed a large command of capital to deal with them. Taking all these facts into consideration, the Directors thought the time had come for them to set to work to still further increase their capital, and their present intention was to issue some new shares. They would, of course, issue them at a premium, and they proposed to offer them to shareholders in proportion to their holdings, so as to give to each one an advantageous opportunity of increasing his stake in the Company. Machinery and buildings, both in this country and in France, were now so complete as to put the Company in a very favourable position as manufacturers. Their prospects, also, he would add, were very encouraging. It was his painful duty to inform shareholders of the death only last week of his old and esteemed colleague, Mr. Neil Bannatyne.

Mr. Abraham Scott having seconded the motion for the adoption of the report,

The **Chairman** invited remarks from any shareholder who might feel in a questioning humour.

Mr. Cochrane was not struck with the brilliancy of the return to shareholders in view of the fact that Directors were handling a reserve fund fully equal to three-fourths of the capital on which dividends were paid—viz., £416,000. He proceeded to criticise the remuneration of the Directors.

Mr. Swete alluded to the way the reserve fund was invested, a subject on which he wanted more information, and also to the remuneration of the Directors, and thought it would be better to make it a fixed sum (at present the Directors receive additional remuneration when the shareholders have received 10 per cent.).

The **Chairman** did not think Mr. Cochrane's general remarks called for any reply. In answer to Mr. Swete, however, he would point out that the way the reserve fund was invested was clearly stated in the assets as being in premises and stock. He then put the motion, which was carried unanimously.

The re-election of Mr. Abraham Scott and Mr. A. Weston Jarvis, M.P., as directors, was proposed by the **Chairman** seconded by **Mr. Marsham**, and carried *nem. dis.*

Mr. Weise having been re-elected auditor, on the proposition of **Mr. Hanson**, seconded by **Mr. Cochrane**,

The proceedings closed with a cordial vote of thanks to the Chairman and Directors, the name of Mr. Matthew Gray, managing director, being specially mentioned.

COMPANIES' REPORTS.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.

The report of the Directors for the year 1891 states that the accounts for the year show a net profit of £85,199, after charging the interest on the debentures. To this sum must be added £61,524 brought forward from last year, making a total of £146,724. From this amount is deducted the interim dividend of 5 per cent., paid July 14, 1891, amounting to £22,410, leaving £124,314 to be dealt with. Of this sum the Directors propose to distribute a dividend of £1. 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2. 8s. per share, or 20 per cent., free of income tax, leaving £57,084 to be carried forward to the next account.

NEW COMPANIES REGISTERED.

Electro-Automatic Fire-Extinguishing Company, Limited.—Registered by Fox and Joy, 59 and 60, Chancery-lane, W.C., with a capital of £12,500 in £1 shares. Object: to carry into effect an agreement, expressed to be made between Charles M. Martin (of No. 8, Imperial-buildings, Holborn Viaduct) of the one part and this Company of the other part, for the acquisition of certain letters patent, patent rights, etc., and to develop and work the same, and to carry on in all its branches the business of a manu-

facturer and vendor of fire-extinguishing apparatus. Registered without articles of association.

BUSINESS NOTES.

City and South London Railway.—The receipts for the week ending 21st February were £827, against £718 for the corresponding period of last year, showing an increase of £154. As compared with the week ending February 7th, last week's receipts show a decrease of £54.

Direct Spanish Telegraph Company.—The Directors have to recommend the payment of a dividend of 10 per cent. per annum on the preference shares, and of 4 per cent. on the ordinary shares, making, with the previous half-year's dividend, a total distribution of $4\frac{1}{2}$ per cent. for the year on the ordinary shares.

Electric Traction.—In connection with another note in this column, we are informed that Mr. W. S. Graff-Baker, who has been the representative of the Thomson-Houston International Electric Company's electric traction system in Great Britain, will continue to devote himself exclusively to the introduction of the system, with headquarters at the Company's offices, 35, Parliament-street, Westminster.

The Thomson-Houston System.—The Thomson-Houston International Electric Company, of 35, Parliament-street, S.W., inform us that they have just transferred all their business in Germany, Austro-Hungary, European and Asiatic Russia, Finland, Sweden, Norway, Denmark, Holland, Belgium, Switzerland, Turkey and the Balkan States, connected with the introduction and use of the Thomson-Houston systems of electric lighting, power, tramways and mining apparatus, to the Union Electricitäts Gesellschaft, of Berlin. The manager hitherto of the Hamburg office of the Thomson-Houston International Electric Company, Mr. Louis J. Magee, will take an active part in the management of the new company, as its technical director. All business in Europe, in countries other than those named, remains under the direct management of the Thomson-Houston International Electric Company, and will be cared for from the general European office of the Company, No. 7, Rue du Louvre, Paris, where a competent staff of engineers will be kept, and from which office all information and estimates will be cheerfully furnished. Mr. E. Thurnauer, who for several years has been in charge of the Paris office of the Thomson-Houston International Electric Company, has been appointed by the Board of Directors the general European manager of the Company, and will have sole charge of all its affairs in Continental Europe, Great Britain, and Ireland. The London office of the Company will remain at 35, Parliament-street, Westminster, S.W., although the lighting business for England and Ireland will be conducted by its long time agents, the Laing, Wharton, and Down Construction Syndicate, Limited, of 38, Parliament-street, S.W.

PROVISIONAL PATENTS, 1892.

FEBRUARY 15.

2913. **Improvements in the electrometallurgic extraction of zinc.** George Nahnsen, 38, Alexander-strasse, Berlin. (Complete specification.)

FEBRUARY 16.

2981 **Improvements in electro-medical appliances.** Percy Albert Craven, 9, King's-road, Wimbledon, Surrey.

2992. **Improvements in systems of electrical distribution of heating currents.** George Dexter Burton, 52, Chancery-lane, London. (Complete specification.)

2996. **An improvement in the construction of electric incandescent lamps.** Frederick Hoyer, 1, Maghill-street, Liverpool.

030. **Improvements in and relating to the lighting of railway vehicles by electricity, and to apparatus therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (The Consolidated Car-heating Company, United States.) (Complete specification.)

FEBRUARY 17.

3112. **Improvements in electric meters.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

3113. **Improvements in generating, transmitting, and utilising currents of high tension, and in apparatus used for these purposes.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

3114. **Improvements in electrical primary batteries.** Charles Thompson, 18, Buckingham-street, Strand, London.

3120. **Improvements relating to galvano-plastics or the electro-deposition of metal** Pierre Henry Bertrand, 4, South-street, Finsbury, London.

FEBRUARY 18.

3145. **Improvements in electric globe and shade holders.** John Whitehead, 42, Anglesey-street, Lozells, Birmingham.

3161. ***Indicator of railway stations by electricity.*** *Julius Heinrich Ahrens, 100, Belsize-road, Swiss Cottage, London.*

3211. **An improved electric switch.** Frederick Brown, 37, Chancery-lane, London.

3212. **Improvements in the application of electric light to roundabouts, and the like, which improvements are also applicable to advertising purposes.** Frederick Brown and Patrick Collins, 37, Chancery-lane, London.

FEBRUARY 19.

3223. **Improvements in apparatus for electrically signalling the engine-drivers or the guards of trains.** George Wilson, Bank-buildings, George-street, Sheffield.

3233. **Improvements in apparatus to be used in connection with electrically-driven machines.** William Stepney Rawson, Charles Scott Snell, and Woodhouse and Rawson, United, Limited, 88, Queen Victoria-street, London.

3234. **Improvements in electrical switches suitable for use in connection with electric launches and the like.** Charles Scott Snell, and Woodhouse and Rawson, United, Limited, 88, Queen Victoria-street, London.

3238. **A gear spring lock action for glass holders of globes used on chandeliers, brackets, electroliers, etc.** Henry Bisseker, 11, New Bartholomew-street, Birmingham.

3240. **Improvements in materials or compounds to be used in the manufacture of moulded articles, such as door handles, insulaters for electrical purposes, boxes, toys, and other articles of the like kind.** James Lang, 35, Southampton-buildings, London.

3244. **Improvements in the method of and apparatus for lighting by electricity circular switchback railways.** William Mitchell, 8, Quality-court, London.

3283. **Improvements in electric arc lamps, specially applicable to search-lights.** John Henry Tonge, and Latimer Clark, Muirhead, and Co., Limited, 24, Southampton-buildings, London.

3291. **Improvements in tubular electrical conductors.** Ernest Payne, 28, Southampton-buildings, London.

3297. **Improvements in electric meters.** Caesar Vogt, 38, 38, Chancery-lane, London.

3300. **Improved means for effecting the connection of electrical conductors.** Clement Johnson Barley, 47, Lincoln's-inn-fields, London.

FEBRUARY 20.

3314. **Improvements in, and relating to, the utilisation of alternating currents of electricity for producing motive power, for charging storage batteries, and for other electro-mechanical and electro-chemical operations.** Charles Barnard Burdon, 71, Raleigh-road, Hornsey, Middlesex.

3366. **Improvements in dynamo-electric machines.** Thomas Lynch Hemming, 12, Cherry-street, Birmingham.

3379. **Improvements in stoves applicable especially to thermo-electric stoves.** William Robert Renshaw, 24, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1880.

3880** **Electric conductors.** (Amended.) Jensen. (Edison Electric Light Company's disclaimer.) 8d.

1887.

16623* **Dynamo-electric generators, etc.** (Amended.) Goolden and Atkinson. 8d.

1891.

2046. **Electrically-propelled vehicles.** Hutchinson. 8d.

4588. **Electric lamps.** Munro. 6d.

5329. **Electric safety lamps.** Bristöl. 8d.

5350. **Electrical dynamo machines.** Harper. 6d.

5404. **Electric, etc., lamps.** Clift. 6d.

5802. **Incandescent electric lamps.** W. and A. J. McGeogh. 6d.

20699. **Electric indicator.** Thatcher and Devereux. 8d.

22785. **Dynamo-electric machines.** Pyke and Harris. 6d.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{3}{8}$
— Pref.	—	$2\frac{1}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	$21\frac{3}{4}$
House-to-House	5	5
Metropolitan Electric Supply	—	$8\frac{5}{8}$
London Electric Supply	5	$1\frac{1}{8}$
Swan United	$3\frac{1}{2}$	$4\frac{1}{2}$
St. James'	—	$8\frac{3}{8}$
National Telephone	5	$4\frac{3}{8}$
Electric Construction	10	$6\frac{1}{4}$
Westminster Electric	—	$6\frac{1}{4}$
Liverpool Electric Supply	5	5
	3	$2\frac{7}{8}$

NOTES.

Dewsbury is anxious to have the best system of central station lighting.

Blackpool Town Council have decided to extend their electric lighting.

Lille.—It is proposed to use gas engines coupled direct with dynamos for the central station at Lille.

Telephone Bill.—We understand that there are over 100 opponents to the National Telephone Bill.

Gloucester.—Why should not the new Gloucester municipal buildings be fitted with electric light?

Dresden.—A committee has been appointed to procure plans and estimates for a central lighting station.

Alternate-Current Motors.—The *Fremdenblatt* newspaper, of Vienna, is printed by alternate-current motors.

Sutton Coldfield.—The promoters of the Sutton Coldfield Electricity and Gas Bill have dropped their scheme.

Paddington Central Station is being proceeded with energetically, much of the machinery being placed in position.

Gibraltar. — The specification for the lighting of Gibraltar by electric light will not be settled definitely until after Easter.

Electricity in Gas Works.—The Compagnie Parisienne du Gaz has installed a complete electrical laboratory in their works.

Electro-Harmonic.—The concert of the Electro-Harmonic Society is a ladies' night to-night (Friday) at eight, at the St. James's Hall (Banquet-room).

The Electric Combination of the Thomson-Houston and Edison Companies in America is to take the name, we hear, of the General Electric Company of America.

Halifax.—The Technical Instruction Committee have resolved to obtain tenders for a new technical school. These ought to and probably will include electric light.

Birmingham.—Messrs. Fowler and Lancaster have been awarded the contract for lighting the Grand Theatre, Birmingham. Both arcs and incandescents will be used.

Scarborough.—A provisional order was obtained last session for Scarborough. Nothing more has yet been done, but it is expected that further steps will be taken shortly.

Burnley.—The Burnley Gas Committee have received the report of the electrical engineer on the supply of the electric light, and resolved to make application to borrow £25,000 for plant.

New Telephone Company Bill.—The second reading of this Bill, for the rejection of which motions had been put down by Mr. Kimber and Sir A. Rollit, has been postponed to the 8th inst.

Edison-Swan Company.—Major Flood Page has been elected a director of the Edison-Swan Company in the vacancy caused by the death of Mr. Leyland, being also elected deputy-chairman.

The St. Pancras Vestry have given notice of the withdrawal of their deposited Bill, under which powers were sought to borrow £360,000 for the electric lighting of the whole of the parish.

East London.—A new electric lighting company is in process of formation, with the object of supplying the electric light to offices and houses and public institutions in the eastern districts of London.

The Institution.—At the next meeting of the Institution, March 10, the discussion on alternate currents will be concluded, and a paper read by Prof. Hughes, F.R.S., on "Oil as an Insulator," illustrated by experiments.

Isle of Wight.—By a majority the Local Board of West Cowes has decided to consent to the application of the Isle of Wight Electric Lighting Company to the Boar' of Trade for powers to light West Cowes by electricity.

Universal Pliers.—Dr. O. May, of Frankfort, has designed a pair of electrical engineer's pliers, which fulfil four purposes—pointed pliers, wire-cutters, metal shears, and hole-puncher. It should be an extremely useful tool.

Roundhay Tramway.—The success of the Rounday electric tramway amongst the inhabitants of Leeds seems perfectly assured, and active steps are being taken to bring into shape the project for a further extension of the line.

Aston.—At the meeting of the Aston Local Board the proposal of the Baths Committee, that the offer of the Free Library Committee to pay £32 per annum for the supply of electric light to the Free Library be accepted, was adopted.

Arc Lamps for Shops.—Where a richly-dressed window is lighted with arc lamps it is sometimes very awkward to get at the lamp for trimming. In Berlin lamps in such places are not suspended, but sent into the window on runners.

Indian Telegraphs.—The telegraph has been extended from Bhamo to Nampoung post on the Chinese frontier. There is now a gap of only 65 miles between the terminus of the English wire and the Chinese telegraph station at Momein.

Coast Telegraphs.—The Clyde Steamship Owners' Association has forwarded to the House of Commons a petition praying for the establishment of a coast line of telegraph connecting all the coastguard stations and lighthouses of the Clyde.

Blackpool Tramway Bill.—The Blackpool Electric Tramway Company, through their agents, have deposited in the Private Bill Office of the House of Commons a petition praying to be heard by counsel against this Bill when it reaches the committee stage.

Physical Society.—At the Physical Society, Science Schools, South Kensington, to-day (Friday), at 5 p.m., Prof. S. P. Thompson will bring forward "Modes of Representing E.M.F.'s and Currents," and Prof. Perry will read a paper on "Choking Coils."

Examinerships.—The University of London, on April 27, will elect examiners (amongst others) in physical science; salaries, £210. The present examiners are Prof. G. F. Fitzgerald, F.R.S., and Prof. Oliver Lodge, F.R.S., who are offering themselves for re-election.

Walsall.—The Corporation of Walsall, as will be seen from their advertisement, are inviting tenders for supply and erection of a central electric light station. Particulars, with plan, can be obtained from Mr. John R. Cooper, town clerk. Tenders to be sent in by April 9th.

Mexborough (Yorks.) Local Board is considering the question of purchase of gas works. Gas is 3s. 6d. a 1,000, which is high for a Yorkshire town. The Board had better consider an electric lighting scheme. They will have to do this some day, and why not now?

Aberdeen Library.—The librarian has been instructed to enquire into the possibility of lighting the building by electricity, and to ascertain if the directors of the infirmary—which, it will be remembered, is already lighted—are in a position to supply current for such a purpose.

British Representation at Chicago.—A meeting of the London Chamber of Commerce will be held on Friday, March 11th, at 3.30, at the Mansion House, under the presidency of the Lord Mayor, in connection with the British representation at the Chicago Exhibition.

Proposed Pacific Cable.—A Reuter's telegram from Sydney states that the New South Wales Government is willing to subsidise the section of the Pacific telegraph cable between Queensland and New Caledonia on condition that Government messages shall be transmitted free.

Boiler Patents.—Models of Messrs. Zahikian and Michaux's patent arrangement for prevention of boiler incrustation, and consequent saving of fuel, are to be seen at 90, Victoria-street, Westminster. A small syndicate is being formed, with offices at 1, Quality-court, Chancery-lane.

Central Station Cranes.—The Gas Committee of the Manchester Corporation invite tenders for the supply of cranes to their electric light station, by March 10th. Applications, accompanied by a deposit of two guineas, to be made to Mr. Nickson, Gas Department, Town Hall, Manchester.

Bulgarian Telegraphs.—With a view of improving telegraphic communication between Adrianople, Philippopolis, and Sofia, the Bulgarian Government proposed to establish a telegraph line between Doblintza, Djoumaa, Eghri-Palanka, and Kustendil. It has been decided to undertake the works.

Municipal Engineers.—The Incorporated Association of Municipal and County Engineers will visit the West Brompton and the Kensington Court electric lighting stations on Saturday, March 12. A considerable number of the members will visit the Crystal Palace Exhibition on the previous evening.

Coventry.—At the meeting of the Coventry City Council on Tuesday, on the proposition of Mr. West it was decided that a deputation from the Council visit the Electrical Exhibition at the Crystal Palace, with the view of obtaining information as to the production and distribution of the electric light.

Lytham Pier.—Mr. J. Stevenson, chairman of the Lytham Pier Company, intends visiting the Crystal Palace Exhibition in a few days, with reference to electric lighting on the pier, the directors contemplating lighting the pier throughout by electricity, a building for the storage of the necessary appliances having already been put up.

Leeds.—The Leeds Town Council have authorised the expenditure of £500 by the Corporate Property Committee to provide a new installation of electric light for the free public library. Alderman Gibson thought it was better at once to remove the machinery to a separate building, as it caused vibration, even if the cost were more. It is proposed to add 133 lights.

Mansion House.—We are asked to notify that the private view of their electric light installation at the Mansion House announced by the Planet Electrical Engineering Company for Tuesday, March 1, has been postponed to Monday evening next, the 7th inst., between 6 and 10 p.m., to enable the Lord Mayor and Lady Mayoress to be present.

Battersea.—At the meeting of the Battersea Vestry last week, the Electric Lighting Committee recommended, with regard to the application by the Putney and Hammersmith Electric Light Company for a provisional order, that [illegible] as the company were prepared to supply electrical [illegible] Vestry should consider the advisability of lighting the public streets by electric light. The matter was adjourned for three months.

New Telephone Company.—A Pioneer Telephone Company has been formed, lists closing yesterday, to take over the Mutual Telephone Company of Manchester, and to provide the necessary capital for the New Telephone Company, Limited (whose Bill is now before Parliament), in the same way as the Pioneer Lighting Company did for the City of London Company.

City Lighting.—The City of London Electric Lighting Company has been making itself pretty evident to financiers lately, not in any occult way, but in the purely practical fashion of taking up the pavements of Old Broad-street to lay their pipes and conductors. Long lengths of streets are now laid, both here and as far as Fenchurch-street Station. The light will soon be at the disposal of the magnates of the City from Aldgate to St. Paul's.

Telephone to Ireland.—We are authoritatively informed that there is no foundation whatever for the report circulated in some quarters that a telephone cable is to be laid to Ireland. No such idea is contemplated. A new telegraph cable is to be laid, which perhaps may have given rise to the rumour of the establishment of a telephone line—an enterprise, however desirable, considered beyond practical range of accomplishment at present.

Omnibus Lighting.—The London General Omnibus Company has found the use of pocket electric lamps so useful to its ticket inspectors that the whole staff is now fitted. The lamps have been supplied by the Bristöl Electric Lamp Company, and the number of lamps amounts in all to 60; they are of 1 c.p. or 2 c.p., weight inclusive 2lb. each, secondary battery. The cost is 8d. per lamp per week. The omnibus company is to be congratulated upon their initiative.

Nottingham.—The Nottingham Town Council decided some time ago to establish a central electric lighting station. They have empowered a committee to draw up a specification of the works and plant required, with an estimate of the cost. The committee have recently visited the Crystal Palace with the idea of informing themselves upon recent progress in electrical practice, but will not arrive at any definite decision without the assistance of one or more experts.

Spanish Telegraphs.—Tenders are required on 10th March by the Direction Generale des Posts, 10, Calle de Carratas, Madrid, for 25,000 porcelain telegraph insulators (1f. 50c.), 3,000 ditto for telephone (80c.), 16,260 poles various sizes, 60 tons 4mm. wire (441f. per ton). Caution-money 5 per cent. Also, 12th March same address, 12,845 poles; 14th March, 20,000 insulators (1f. 50c.), 85 tons bronze wire, 3mm. (3,200f. per ton); and 26th March, 40,000 zinc cylinders.

Minehead.—Mr. G. Hayward has had the electric light introduced into his mineral-water factory and other parts of his premises. The installation consists of a 40-light compound-wound dynamo driven by a 3-h.p. Otto high-speed gas engine. The wiring of the premises and fixing all the various lamps, switches, fuses, and other fittings were entrusted to Messrs. King, Mendham, and Co., of Bristol, Mr. R. Clark and Mr. M. Capron assisting their electrician, Mr. A. Rouch.

Derby.—At the meeting of the Derby Town Council on Wednesday, the Mayor moved that the Electric Lighting Committee be authorised to take steps to obtain an extension of time for the laying of the electric mains in the compulsory area of the borough as defined by the electric lighting order, 1890. He stated that the time under the

present order would expire on August 4th, and he understood from Sir Frederick Bramwell that if an extension was granted it would not exceed three months. The motion was agreed to without discussion.

Gas Engines for Theatres.—The London County Council have adopted a series of rules and regulations with regard to the electric lighting of theatres and other places of entertainment. One is that gas engines employed in this connection are to be placed in rooms so adequately and continuously ventilated that no explosive mixture of gas can accumulate by any leakage from the engine in the event of any of the gas-cocks being left turned on. A hood, connected with a pipe carried into the external air, is to be fixed over the ignition-tube, when this is used.

Electric Traction Finance.—A meeting of the Society of Engineers will be held at the Town Hall, Westminster on, Monday next, March 7th, at 7.30 p.m., when a paper will be read on "Electrical Traction and its Financial Aspect," by Mr. Stephen Sellon. The following is a synopsis of the paper: Object of paper; accumulator system; overhead system; conduit system; National Telephone clauses; Roundhay electric tramway; working expenses in America; Blackpool electric tramway; Waller-Manville system; the commercial question; cost of construction for horse, cable, and electricity; comparison of working cost for each system. Visitors are admitted.

Band Music by Telephone.—An interesting and amusing instance of the efficacy of the London-Paris telephone occurred the other day which is worth recording. The Salvation Army band were marching from the Royal Exchange playing the "Marseillaise," when an idea struck the members present in the telephone-room. The windows and doors were thrown open and the attendant at the Paris end was asked if he could hear anything. The response (in French) was immediate, "Yes, I can hear a band playing the 'Marseillaise.'" That a band of music playing in the streets of London could be plainly distinguished in Paris is, we think, a sufficiently striking marvel of the nineteenth-century science.

Dynamo-Electric Machinery.—The new edition of Prof. Silvanus Thompson's work on the dynamo will be published in about a fortnight. Considerable alteration has been made, the whole has been practically rewritten and brought up to date, large additions have been made, and an appendix containing diagrams and working drawings greatly add to the usefulness and practicability of this most useful and practical of technical books. The size will reach 800 pages, and the price, we understand, will be slightly raised, making the net selling price equal to the present published price—viz., 16s. The appearance of the new edition has long been awaited with interest by students and engineers alike.

Incandescent Lamp Manufacture.—The Edison-Swan patents have only two years to run. Is it worth while to fight? Apparently not, for the letter issued by the Sunbeam Lamp Company, hitherto left in peace to make high candle-power lamps, says: "We much regret to have to inform you that owing to the action taken by the Edison and Swan Company, we shall be unable during the continuance of the Edison patent to meet any more of your valued orders for Sunbeam lamps. We have consented, rather than enter into a costly litigation with the Edison and Swan Company, and in view of the early expiry of both their patents, to suspend their manufacture." The Edison Company are warning not only makers but all users of lamps against using other than those of Edison-Swan manufacture.

Automatic Messenger Call-Box.—A very ingenious automatic machine has been established near the letter-box at Charing Cross railway station for the collection of letters to be forwarded by the Post Office express service. It is in electrical connection with the postal telegraph office opposite the station. By dropping a penny into the slot and pulling out the slide a brown-coloured envelope is delivered. This envelope contains another envelope and a card. The communication is intended to be written on the card, which is then enclosed in the white envelope, and this, with the fees for delivery, which have been fixed at 3d. per mile, is re-enclosed in the outer envelope and deposited in the box behind the flap which bears the printed instructions. The act of withdrawing the slide sends the call signal to the telegraph office, and a messenger is at once despatched to collect the special letters.

Bulgarian Telegraphs.—Tenders are notified by the French Minister of Posts and Telegraphs until March 8, at the Commission Permanente de Sofia, under seal, for 37,000 kilogrammes of telegraph wire of 4mm., 500 kilogrammes of 2mm. wire, 11,000 insulators, and 11,000 brackets. These are to be furnished as follows: at Lom Palanka, 15,000 kilogrammes of 4mm. wire, 3,500 brackets and insulators; at Rustchuk, 1,200 kilogrammes of 4mm. wire, 4,000 brackets and insulators; at Sofia, 10,000 kilogrammes of 4mm. wire, 500 kilogrammes of 2mm. wire, 3,500 insulators and brackets. Separate tenders can be sent if desired. The total value is limited for the 4mm. wire to 18,500f., 2mm. wire 300f., brackets 7,000f., and insulators 10,000f.—a total of 1,790f. Deposit-money is required. Further details at the Sofia Commission Office, or of the Bureaux des Renseignements Commerciaux, 80, rue de Varenne.

Salford.—At the monthly meeting of the Salford Borough Council on Wednesday, Mr. Phillips moved a resolution of the General Gas Committee that it was expedient that the Corporation exercise within the borough the powers conferred upon them by the provisional order for electric lighting. The committee had in view in adopting a scheme to agree only to have a comparatively small installation, which would preserve to the borough the right of electric lighting, and as occasion arose afterwards extensions might be made. The Board of Trade had sanctioned a small area, and the lighting would be confined at present within that area. An amendment was moved that the exercise of the powers should be postponed, there being no need to fear terrible results from the establishment of a private company. The amendment was lost by a large majority. Mr. Phillips explained that the cost of the first installation would be £15,000 to £20,000.

Liverpool.—At the meeting of the Liverpool City Council on Wednesday, Mr. Hornby moved the adoption of the recommendation of the Watch Committee that the Board of Trade be informed that the Corporation were willing to withdraw their opposition to the Liverpool electric lighting provisional order, 1892, and to give their consent to it being granted, provided it was amended in accordance with the terms approved of by the committee. Mr. Hornby explained that this was a fair compromise, the Corporation securing power to purchase the undertaking after the lapse of a certain period. At particular intervals the Board of Trade might be approached, and might alter the mode and amount of payment. Alderman Dr. Cross ascertained that provision had been made for regulating the price of the electric light to the public, according to the increase of dividend. When the dividend was over 7 per cent. the surplus was to go towards the reduction of the price. The recommendation was confirmed.

Tesla Apparatus.—Our readers will be interested to learn that a Tesla experimental apparatus is being con-

structed for lecture purposes at the Finsbury Technical College. The students will be very much on the *qui vive* the first time Dr. Thompson ventures to take the million-volt shock into his body. Some one must evidently follow suit to Mr. Tesla, but we have heard the opinion expressed by several engineers that they would hardly like to build and test such an apparatus with a trust in its harmlessness merely from abstract or mathematical reasoning without trying it, say, on a calf first. Mr. Tesla has a splendidly-equipped laboratory in New York, and the experiments he showed at the Royal Institution are by no means all he had to produce, given more accurately determined conditions. With the experimental skill of Finsbury also turned on to this new branch of electricity—the "vibratory current" system—we may soon see electric lamps without wires—primitive, no doubt, but yet alight—amongst the regular course of lecture demonstrations at technical colleges.

Manchester Central Railway Station. — The Central Railway Station at Manchester has been brilliantly lighted by 40 arc lights of 2,000 c.p., distributed over the platform and approach. The offices, refreshment-room, and bookstalls are lighted with incandescent lamps of 16 c.p., handsome electroliers being supplied in the public rooms. The generating plant is placed under the arches beneath the viaduct, the cable being led along the line to the station. Two powerful compound engines have been supplied by Messrs. Mather and Platt, driving Edison-Hopkinson dynamos. The boilers are by Messrs. Galloway, and the whole plant is in duplicate, with special arrangements for interchange of service. The general arrangement of the lighting has been arranged by Mr. W. G. Scott, the chief engineer of the Cheshire Lines Committee, who are so well pleased with the results that they have commissioned Messrs. Mather and Platt to make the necessary increase in the plant for lighting the whole of the goods department. Active preparations are now being made for the erection of 76 1,000-c.p., 10 2,000-c.p. arc lamps and 65 16-c.p. incandescent lamps. The whole of the gas will then be replaced by the electric light, the installation forming one of the most important which has yet been supplied to any railway company in the kingdom.

Stone-Carving by Electricity.—Electricity has now been put to many uses, the very latest being the working of a machine which it is thought will revolutionise the art of stone carving. The inventor is a Colorado man, Mr. W. P. Carstarphen, and the invention is described in the Denver *Sun*, and consists of a small reciprocating electric drill. The tool is provided with a reciprocating plunger, located and moving within the two solenoids of insulated copper wire, through which a direct current of electricity is alternately passed. The current for operating the tool can be supplied from any suitable electrical source, such as an ordinary primary battery or a dynamo, and is simultaneously switched from one coil or set of coils to the other by the use of an automatic switch placed between the two coils and controlled by the reciprocation of the plunger. The current is led to one end of the tool through a revolving swivel, and the rapidity of the strokes made by the plunger is regulated by a button on the side of the tool. In the model, which is a 3lb. tool, the stroke can be made to vary from ⅛in. to 1in., with a motion varying from 50 to 300 strokes per minute. To run a tool of this size from four to six volts only are required. Portable storage batteries, 12in. by 6in. by 6in., have been made, which are encased in a neat box, and intended for operating the tool on scaffolds and elsewhere away from the shop. These have energy *sufficient for a day's* work, and can be recharged overnight at an expense not to exceed one shilling. With this tool the carver or sculptor instead of dividing a portion of his attention to striking his chisel, can devote his entire attention to the lines which he is following, thus producing more accurate and rapid work. It is estimated that the machine will produce work in one-fourth the time of hand work, and therefore a material reduction in the cost will be secured. Although 6lb. is the heaviest tool constructed thus far, the principle of the machine can, it is said, be carried into those of endless variety and size, and suited to all purposes, from the most delicate sculpture work to the heaviest of granite drilling and mine work.

Electric and Cable Railway Schemes.—In the House of Commons on Tuesday Mr. Whitmore moved: "That a Joint Committee of Lords and Commons be appointed to consider the best method of dealing with the electric and cable railway schemes proposed to be sanctioned within the limits of the metropolis by Bills introduced, or to be introduced, in the present session, and to report their opinion as to whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and probable future traffic; as to whether any, and which, of the schemes propose satisfactory lines of route; as to the terms and conditions under which the subsoil should be appropriated; whether any, and, if any, what, schemes should be proceeded with during the present session; that a message be sent to the Lords to communicate this resolution, and desire their concurrence." He urged, in support of the motion, that the proposal was supported by the Corporation and the County Council of London. He justified his proposal for the creation of an unusual tribunal by pointing out that electric and cable schemes were very numerous and very important, and that it would be well for the future comfort and convenience of London if, at the outset, an authoritative enquiry by such a joint committee as he suggested took place instead of referring Bills to different committees. Mr. T. H. Bolton, in rising to second the resolution, said that he believed the reference would cover all the important questions which might arise in connection with these railways. Mr. Kimber moved, as an amendment, to add the words, "Provided that such committee, before reporting that any schemes for which Bills have been deposited should not be proceeded with, shall have first heard the parties promoting such Bills, and, if desired by them, receive evidence thereon." Mr. Courtney thought that the present would not be a convenient time to move the amendment, and suggested that it should be withdrawn. The amendment was then, by leave, withdrawn. Mr. Isaacs, while entirely concurring in the resolution, hoped that the committee would lay down some condition by which promoters of any of these schemes would not be allowed to interfere with the metropolitan lines. The resolution was agreed to.

Croydon Tramways.—At the fourth half-yearly general meeting of the Croydon Tramways Company held on February 23rd at The Guildhall Tavern, Gresham-street, Mr. W. J. Carruthers-Wain (the chairman), with reference to the question of traction said: "We have taken a step in advance, I think, which I hope will redound to our credit and to our spirit of enterprise, on the principle of heads we win and tails we don't lose. In other words, we have made arrangements with the Electric Tramcar Syndicate, who have placed cars on our lines, that we shall pay them so much a mile, that amount which we are paying them per mile not being more than it costs us for horse traction at the present time, and the surplus being our property. I have had some figures prepared, showing the miles run by the electric cars since they were first put

on. Of course, they have been running under difficulties of weather and of incomplete installation, and other things which a technical mind would easily understand; but those difficulties are being rapidly remedied, and I believe the cars will be run very successfully. If they are not, it will not be the fault of the inventor, Mr. Jarman. The number of miles run by the electric cars in the month of January was 662, and they earned £39, which come out at the rate of 1s. 2½d. per mile run. That, in such a month as we had in January, is marvellous. Something is due no doubt to the novelty of the traffic, but I go a little further than that, for I believe that once you attract the public by a novelty, you attract them afterwards. 1s. 2½d. is a return which is not excelled by any other company, not even the great companies. It is equalled by one, but it is not excelled by any. That is an instance of the popularity of the electric cars and of their success. There may be a few mechanical alterations required, but so long as the financial part of the burden does not fall upon us, I think we should do all we can to help the syndicate to make the experiment successful from their point of view. It has been suggested that we should buy the cars and put up an installation. Nothing would give me greater pleasure, if we had the money; but as we have not, and while people are ready to come forward and put cars on our line, we can only say that we will help them to the best of our ability. We have no money to re-equip our line either with these cars or any other cars. If this experiment is a success, I have no doubt the Electric Tramcar Syndicate will be only too glad to put on more cars, for their own benefit."

Manganin.—Prof. Ayrton in his presidential address alluded to the lack of knowledge of many electrical engineers to the new German alloy "manganin," which constitutes a most useful material for the construction of electrical resistances. We have received the following particulars with reference to this alloy from Messrs. Abler, Haas, and Angerstein, of 18, Kommandanten-strasse, Berlin, and 23, Great St. Helens, London, the sole agents in the United Kingdom and abroad: Manganin is an alloy of manganese, copper, and nickel, especially suitable for electrical purposes. It is recommended by Dr. K. Feussner and Dr. St. Lindeck of the Government Physico-technical Laboratory in Charlottenburg (Berlin). Manganin has, according to the researches carried out in the above-mentioned laboratory, this most important quality, that it undergoes an almost inappreciable change of resistance with the variation of temperature. (See Dr. K. Feussner and Dr. St. Lindeck, *Zeitschrift für Instrumentenkunde*, 1889, p. 233; *Zeitschrift für Instrumentenkunde*, 1890, pp. 10 and 427; *Elektrotechnische Zeitschrift*, 1890, p. 243). In the range between 0deg. C. and 15deg. C. the resistance slightly increases at a mean rate of 0·002 to 0·003 per cent. From 15deg. C. to 30deg. C. (which is the common range of temperature in electrical measurements) the change of resistance is imperceptible even to the most delicate observations, the actual change being only a few millionth parts per degree. At higher temperatures the resistance slightly diminishes. This is the first authentic record of a metal diminishing in resistance with rise of temperature. The specific resistance of manganin is 42 microhm per centimetre cube, which is much higher than the resistance of other German-silver alloys. The specific resistance of manganin permits the use of much smaller resistance-boxes, when the coils are made of this material. On the other hand, when it is employed for current-regulating resistances stronger currents can be used with the same amount of material. In consequence of these qualities manganin is a most important material, not only for resistance-boxes, for which it is highly recommended, but also for voltmeters, and in general for all kinds of electrical apparatus in which constancy of resistance at different temperatures is required. The use of manganin gives, therefore, much more trustworthy results than any resistance material hitherto known. Manganin being very soft and pliable, tubes without seams can be drawn for resistance purposes. These tubes are supplied up to two metres in length and in various diameters. Samples, testimonials, and further information may be obtained on application at the London office, 23, Great St. Helens, E.C. It can be obtained in bare or in silk-covered wire, and in plates from 0·1 mm. to 4 mm. thick.

Cambridge. — At the quarterly meeting of the Cambridge Town Council held recently the Electric Lighting Committee reported: "That the Town Council has received an official communication from the Local Government Board, in answer to the application of the Corporation for permission to borrow the sum of £35,000 for the purpose of electric lighting, giving the sanction of the Board to the borrowing by the Corporation of £25,840 for the above purpose. This sum is, in the opinion of the committee, not sufficient to enable the Council to carry out the scheme proposed by Prof. Garnett, so far as regards any part of the town outside of the compulsory area described in the provisional order. Messrs. Parsons and Co. have made a proposal to the committee to form a company for taking over the powers and duties of the Corporation under the provisional order. The committee recommend that they be authorised to negotiate with Messrs. Parsons and Co. on the basis of their proposal, and that, failing a satisfactory arrangement with them, the committee be at liberty to negotiate with some other firm or company for the taking over of the corporate powers." Alderman Whitmore, in proposing the adoption of the report, said it would have been better if the Local Government Board had given them sufficient money to go on with the entire work. They had only granted £25,840—merely the sum required to supply the prescribed area, and not sufficient to carry out Prof. Garnett's scheme. He thought they ought to have sufficient money to extend the lighting to the whole of the town. Mr. Vintner opposed any grant from the rates to light any portion of the town; but he thought the advantage of the light should be within the reach of every inhabitant of the borough. He hoped that it would be distinctly understood that any negotiations commenced would be upon the basis of property reverting to the Corporation upon reasonable terms and within a reasonable period. He thought the application had not been properly submitted, as the loan of £25,840 did not admit of one shilling for an alteration of plant or extension of mains. Mr. Morley said the report was not worded according to what the committee had decided. Their idea was to ask the company for their terms, and then bring forward two reports—one giving the cost for the Council to do the work itself, and the other the terms of the company. He suggested the mover allow the following words to be added: "And bring before the Council two schemes—first, for the Corporation lighting the prescribed area itself; and, second, the offer of any company." Mr. Flack proposed, as an amendment, that the report should be referred back to the committee. Mr. Huddleston seconded, remarking that he trusted the report would go back with an understanding that if the company took the risk it should have the profits also. It was not to be supposed that any company would accept a contract for seven years also. After further discussion, in which it was maintained that there was no reason for the report being referred back, the amendment was defeated and the report adopted.

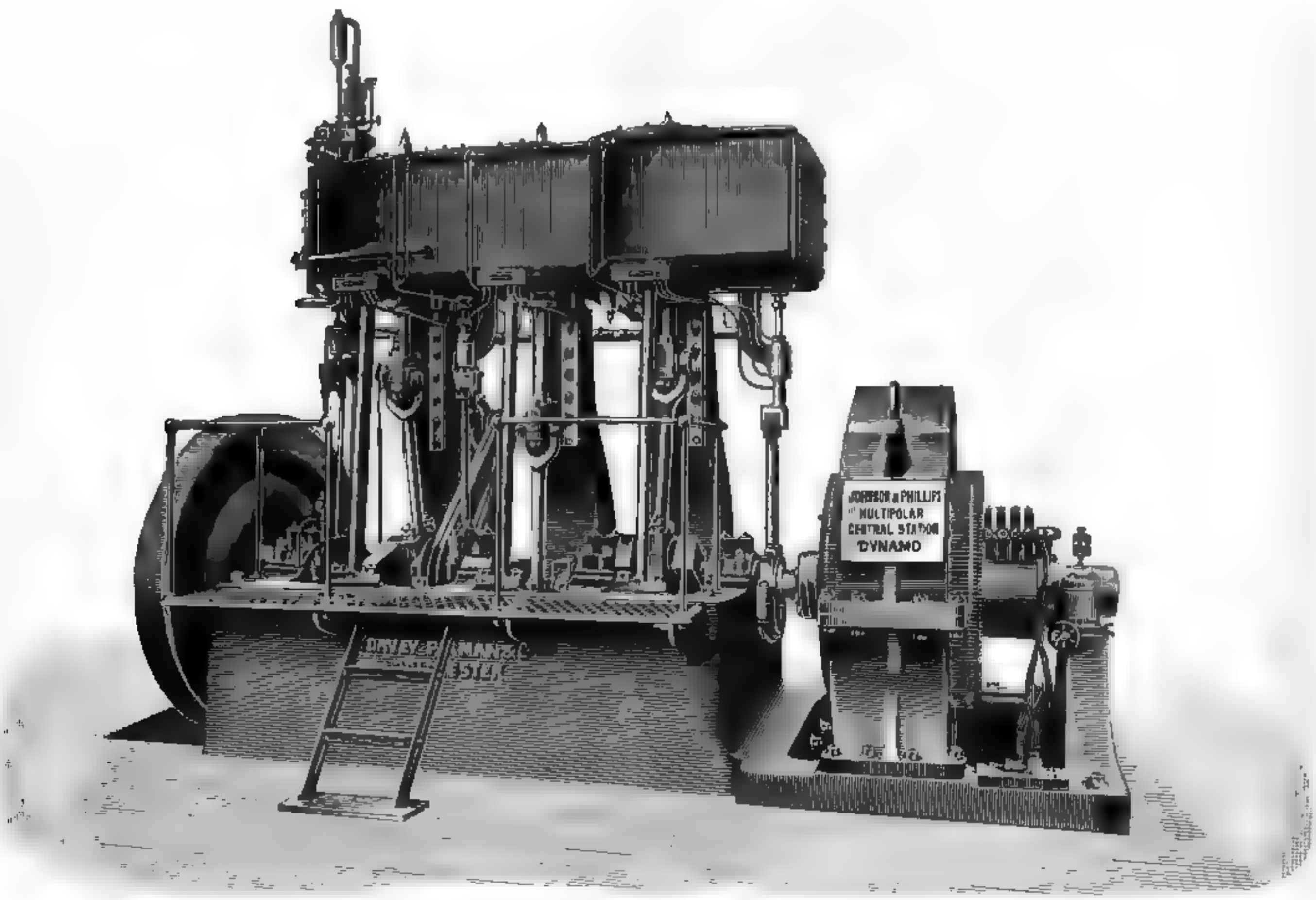
THE CRYSTAL PALACE EXHIBITION.

Although the Exhibition may now be looked upon as practically complete, a correspondent points out that even after this lapse of time from the opening the exhibitors have not placed all the exhibits in position which they necessarily led the editor of the catalogue to believe would be shown. The compiler of a catalogue is perforce compelled to take his lists of exhibits from the exhibitors, and it is the duty of the latter to install as quickly as possible the apparatus named. As we pointed out last week, the Crystal Palace authorities notify deputations, but there are visitors, really deputations, whose visit cannot be foreshadowed, yet these visits will lead to business. Take, for example, the Lytham Pier Company—a company which is now erecting a pavilion at the head of the pier. The chairman of the company is coming to London within the next few days to enquire into the matter of lighting the pavilion by electricity. Such orders are not large compared with central station work, but they are worth having, even if only from the view that "business" leads to "business."

From the exhibitor's point of view, the most important visitors of this next week will be the members of the Incorporated Association of Municipal and County Engineers, who are to be expected on Friday, March 11th. According to present arrangements, the members will visit the Palace on Friday evening, and on Saturday, among other visits, will see the West Brompton House-to-House station and the Kensington Court station.

In our last issue we described the motor-generator in use by the District Company for much of the Palace lighting, a slightly modified form of which is to be seen at the Electric Construction Company's stand in the Machine Department. A little further down the Machine Room is the conspicuous exhibit of **Davy, Paxman, and Co.** and **Johnson and Phillips**, the former showing, among other things, a three-cylinder engine coupled direct to a Kapp dynamo, built by Messrs. Johnson and Phillips.

The illustrations represent the large steam dynamo, as we say, jointly exhibited at the Crystal Palace by Messrs. Johnson and Phillips and Messrs. Davey, Paxman, and Co. The machine has eight field poles projecting radially inwards from a massive cast-iron yoke ring. The magnet cores, which are cylindrical, are 14½in. diameter, and the rectangular pole-pieces are also of cast iron. To facilitate the insertion of the armature the yoke is made in halves with horizontal joints; the top half can be removed by the lifting rings. The armature core is 48in. diameter by 18in. long, and is built up of segmental plates threaded on steel bolts and secured between strong cast-iron cheeks. The power is transmitted to the armature conductors by 64 metal driving horns, insulated with fibre and mica, the force transmitted by each driving horn being about 50lb. There are 362 bars on the armature, and the ends are connected by segmental plates insulated from each other and mounted in cast-iron carriages, which latter are screwed to the end cheeks above mentioned. This method of end connections has the advantage of leaving the ends of the armature perfectly open, which admits of excellent ventilation inside and of avoiding the crossing of conductors over the ends, which in the old-fashioned way of drum winding is so frequently a source of trouble. The difference of potential between adjacent plates is only 10 volts.



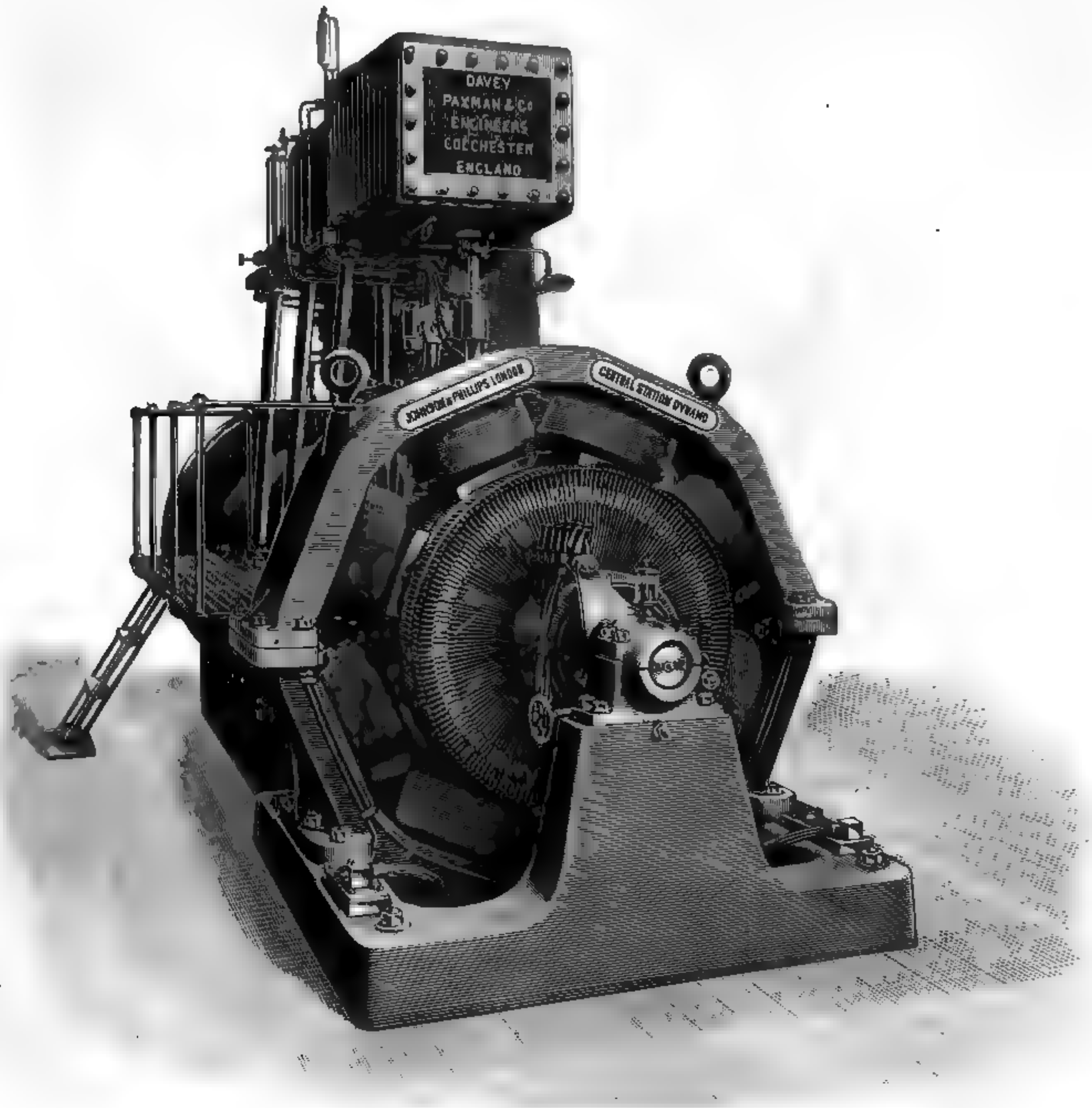
Paxman Engine Coupled to Kapp Dynamo.

The commutator contains 181 sections, and is 21in. in diameter and 12in. long. The current is taken off by two sets of brushes placed 135deg. apart, four brushes in each set. The machine is designed for an output of 550 amperes at a voltage which can be varied at will, from 200 to 260 volts. For charging batteries when a smaller current is required towards the end of the charge, the voltage may be forced up to 300 volts. The speed of the machine under all working conditions is intended to be 130 revolutions per minute, but as at the Crystal Palace a voltage of 205 volts only is required, the engine governor has been adjusted for a speed of 115 revolutions per minute. The exciting power of the field magnets can be varied by means of a rheostat so as to adjust the voltage within the limits above mentioned. The brushes are adjustable by worm gearing. The current from the machine is used for lighting the Picture Gallery by incan-

descent lamps (which have been fitted up by the Gulcher Company), also for some Gulcher arc lamps, and for a number of Brockie-Pell lamps, as well as for driving all the machinery on Messrs. Johnson and Phillips's stand. For the latter purpose the current is passed through a pair of small balancing dynamos, which split up the voltage into 70 and 130 volts, so as to make the current suitable for charging cells and work the ordinary type of machines exhibited on the stand.

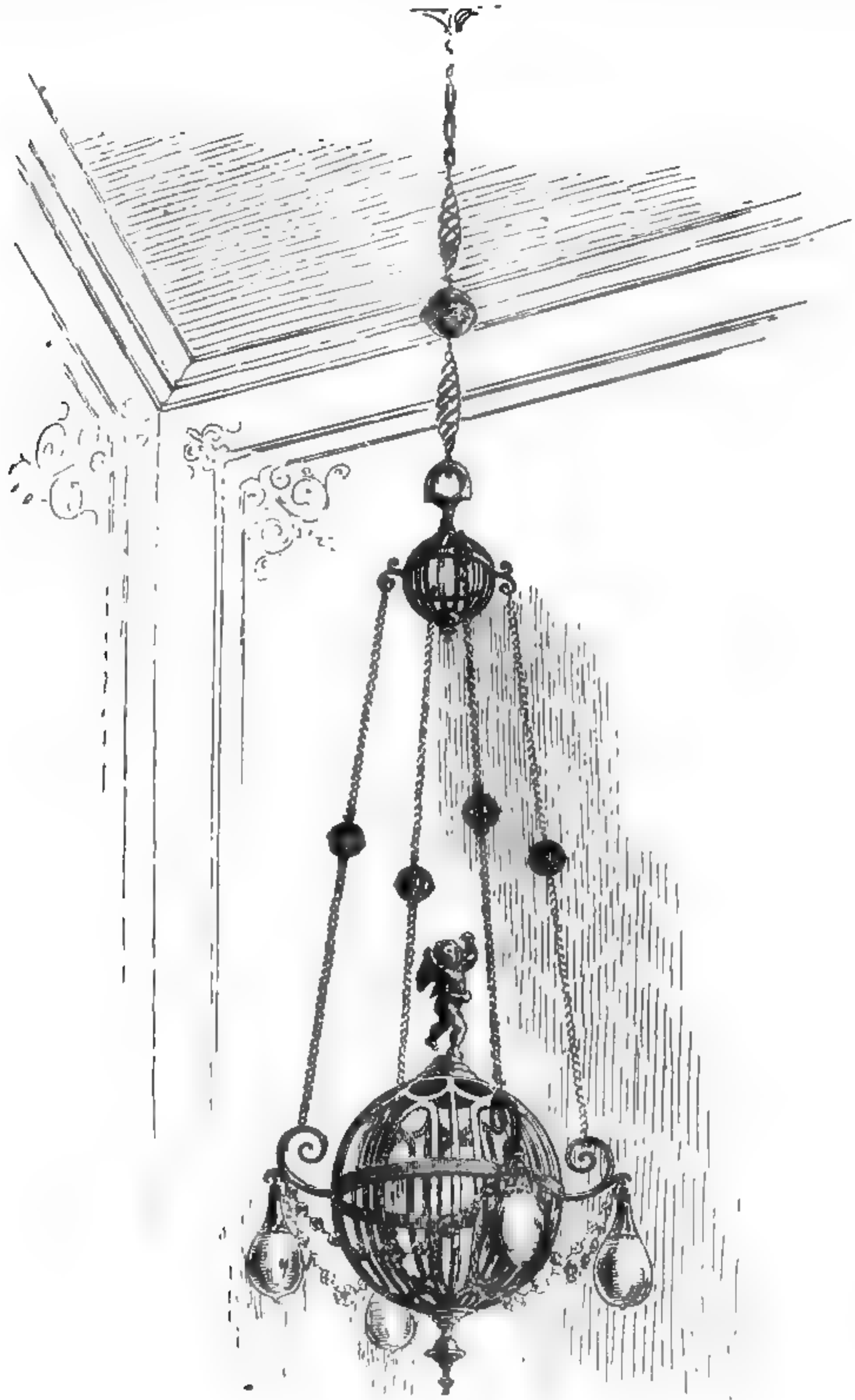
The engine is triple expansion, having cylinders 12in., 18¾in., and 30in. diameter respectively, with a uniform stroke of 18in. It is built for an indicated horse-power of 350, at 140 revolutions, or 320 i.h.p. at 130 revolutions and 160lb. steam pressure. The floor space, including platform, is 10ft. 6in. by 6ft. 9in., and from the floor line to top of cylinder covers is 11ft., the extreme height to top of sight-feed lubricators being 3ft. 2in. more. The platform is 2ft. 8in. above floor level. The steam is supplied from Paxman's patent water tube boiler at 130lb. pressure, and for the purpose of starting the engine in any position steam can be admitted direct into the intermediate steam-chest. The crankshaft is of mild steel, with slotted cranks 120deg. apart, and runs in four long bearings. The governor is of Paxman's improved design, extremely sensitive, keeping the engine under absolute control. When the governor lifts it pulls over a link, bringing the short-throw eccentric into action with expansion valve spindle, and cuts off steam earlier, keeping the speed constant. The three main eccentric rods are of best forged iron, finished bright, with adjustable brushes. The automatic gear is of steel, with forked joints, fitted with steel pins. The piston-rods, cross-heads, slippers, and valve spindles are of forged steel, the latter being swelled to work in guides. The connecting-rods are of best forged iron; the flywheel is 6ft. diameter.

Among the numerous displays of artistic electric light fittings at the Crystal Palace Exhibition, we think the palm for general elegance, beauty, and fitness of designs for the electric light must be given to the stand of **Messrs. Faraday and Son**. Other displays there are of great beauty, especially where cut glass is extensively called into play, as is the case with one well-known stand, and many exhibitors show a great variety of elaborate and fanciful fittings, which are more or less suitable for the artistic decoration of houses with electric light. But if we examine quietly the many beautiful fittings at Messrs. Faraday's stand, the individuality and appropriateness of the designs there shown are very striking. And when it is mentioned that the electric fittings at the exhibit which everyo acknowledges to be one of the features of the Exhibi that of Messrs. H. and J. Cooper—have been out by Messrs. Faraday and Son, it will wrought standards firm take in the present Exhibition, as ich are so designed as a very high place in commending itching upon the wall for light to the public.



Kapp Dynamo Coupled to Paxman Engine.

The stand itself is very characteristically fitted up, with walls hung with serge of a soft green tone, the columns, arches, and recesses being draped with velvet of warm harmonious tints. The stall is roofed, with diaper ceiling, and outside the front is canopied by a silken awning supported with Syrian spikes. Indian matting and Persian rugs cover the floors. On two sides small recessed Georgian windows are prettily inserted, shaded with ferns in pots, and through these windows delightful glimpses of the long galleries, or the tropical palms and ferns that encom-
ththem, can be obtained by the visitor.
Departi is laid on for over 100 lamps, which are mounted
the conspif.fittings. In the centre of the wall is a fine
and **Johnson** al Faraday, lighted by a suitable picture
other things, a themiling down on the handsome exhibit
Kapp dynamo, built bythe lights that glisten from all
*The illustrations repre*alleries. In the centre o! the

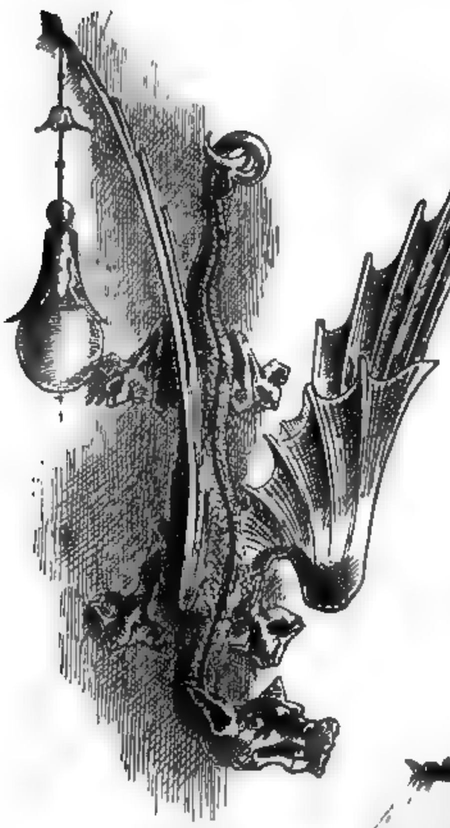


Drawing-room Pendant by Faraday and Son.

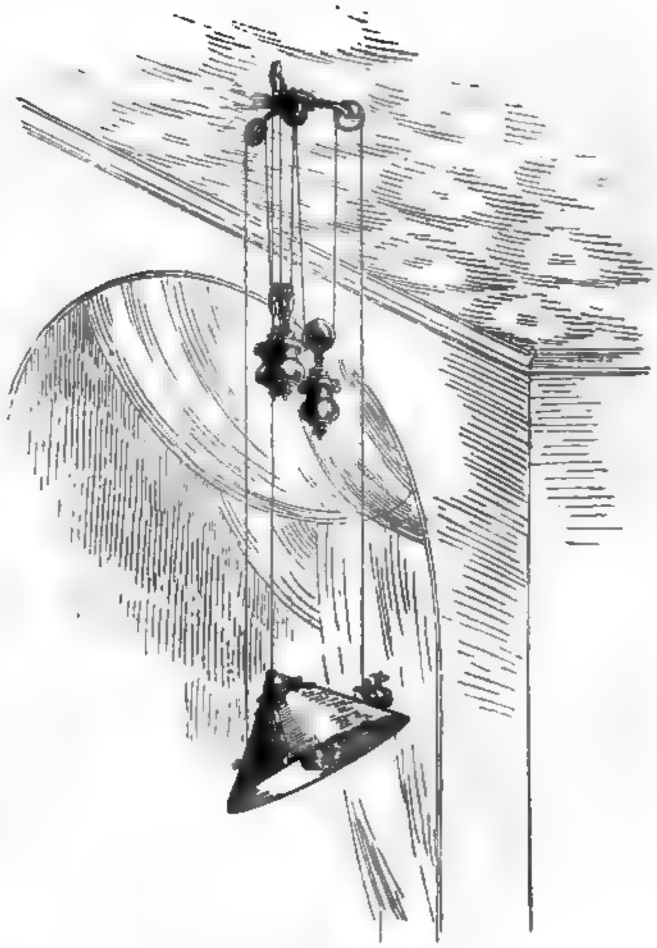
stand is a large electrolier in silver for 15 lights, suitable for a large drawing-room, the five triple sprays being supported by caryatides. From the centre also hangs a fine ballroom chandelier in chased metal, with crystal hangings. A speciality in this exhibit is that of fittings having tasseled bead shades hung around the incandescent lamps, which give a pleasing subdued glow and suitably replace the glass, silk, or paper shades. A five-light chandelier of delicate design is thus fitted, and has a handsome appearance. Other smaller pendant lamps are also fitted with these tasseled golden beads, and others with silver tassels of the same kind.

Persons of taste, with a desire for originality, will notice with pleasure the swinging pendant of a flying dragon carrying three lamps, while the reproduction of Pompeian oil-lamps, with their flame represented by a torch-shaped frosted incandescent lamp, has a very pleasing effect.

Another to be noticed is a light and graceful globe of open metal, swinging by chains and surmounted by a figure of Cupid with his bow. Little cupids in fact, are several times invoked to add the antique mythical flavour to the soft light of the electric lamp, as for corners of boudoirs or in the canopies of beds.



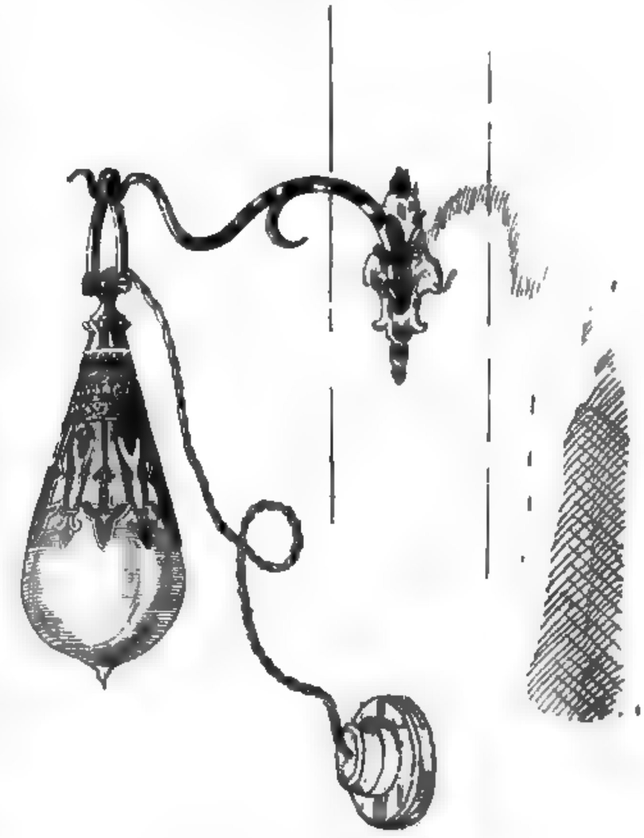
Dragon Bracket.



Sir D. Salomon's "Perfect" Pendant.

Faraday's Filagree Pendant.

Table Standard.



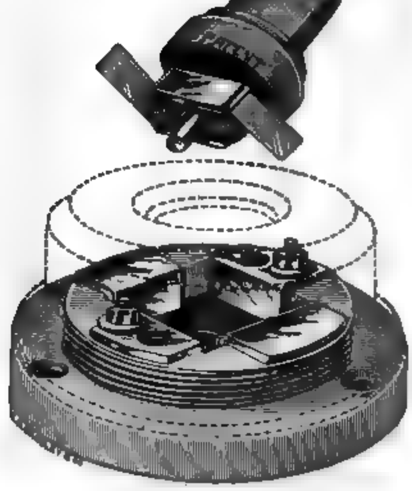
Faraday' Movable Side Lamp

The flying figure of Mercury, with wand and winged sandals, carries a lamp at extended arm length, while a Bacchus also forms a tasteful stand for the same purpose. There are quite a variety of chased and wrought standards for portable table lamps, some of which are so designed as to be equally suitable also for hitching upon the wall for

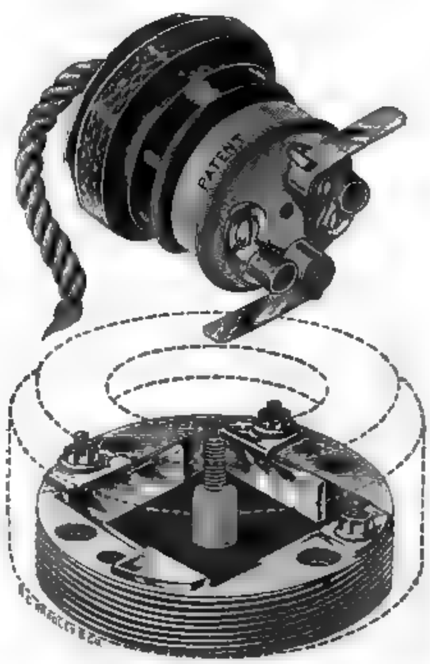
use as brackets or over-bed lamps, the shades being fitted on trunnions for reversing. A portable table lamp in nickelled silver, with sliding arm with a revolving action for a shaded lamp, is also to be noticed. There are several counterweight pendants specially designed for dressing-tables and for reading-desks.

A noticeable counterweight pendant, of peculiar design, is that termed the "Perfect," designed by Sir David Salomons, and of which Messrs. Faraday are the sole makers. A reflector of suitable design is suspended by three cords, each having a counterweight. The pendant has then the peculiar advantage that it may be canted so as to illuminate or cast into shade any portion of the room at will. It is equally adapted to large or small lights, and to cheap or costly fittings. That shown is suitable for a library or writing-desk, and is prettily finished with small dolphins. Several of Messrs. Faraday's fittings are furnished with quaint designs of winged dragons or dolphins in bronze, also goats, ram's heads, swan's necks, and so forth, in wrought, gilded, or oxidised metal. These are worked into the wall fittings combined with the very elegant lampholder long introduced by Faraday's, now made sufficiently large to contain the bayonet-jointed lampholder as generally used. These socket holders can be of the kind now rendered fashionable by this firm. Sanctuary lamps are also seen, swung by chains, and moulded on old forms taken from Spanish and Florentine originals of the sixteenth century, and these in pierced and embossed hand-worked metal are peculiarly effective in toning the glare of the electric light for quiet corners.

In the "Princess Christian" rooms of Messrs. Cooper's exhibit, Messrs. Faraday have a variety of fittings in place. There we find wrought-iron lobby lanterns, winged dragons carrying lamps, figures of Mercury and Iris holding lamps, besides dolphins and cupids. In the Oriental room is a reproduction of a Cairene brazier, Arabian painted glass pendant vases, besides the centre pendant. The dining-table is fitted with a handsome centre pendant, the bedroom with silver Louis XVI. dressing-table bracket, Greek tripod writing-table standard, pierced silver pendant, and cupid lamps at the bed head. A very comfortable easy reading-chair is fitted with movable electric bracket, as illustrated in Mrs. J. E. H. Gordon's delightful book on electric light decoration. Japanese and Moresque fittings are interspersed in corners, and the whole set of rooms diffused with a soft and lovely glow. No one who visits the Exhibition should leave without a good look at Messrs. Faraday and Son's exhibits.



A. P. Lundberg's "Unique" Switch.



The "Unique" Combination (Switch Wall Socket).

S. Smith and Son's Non-Magnetic Watch.

obtained alone in different material, hammered brass or gilded metal, in the graceful forms of the lily, the tulip, or the lotus, making the simple frosted incandescent bulb into an harmonious thing of beauty.

Besides these fittings proper Messrs. Faraday show a variety of shade-holders, or supports, in cast or pierced metal, also floral in treatment. Screens, shades, and light diffusers of various patterns, and mantles of sober tints soften the glare of the naked electric light. Some lovely samples of real Venetian glassware are also shown. One method now very usual in high-class houses is well illustrated in this exhibit. This is to use wall brackets or candlesticks with the globes screened by shells or tapestry shades from the eyes. These are made in a large number of different shapes and tints, and produce a very beautiful effect in a handsomely-decorated room.

Of switches and safety fuses Messrs. Faraday show some of their own design of fireproof material, but avoiding the usual mechanical appearance given by many makers to these necessary adjuncts. Being comparatively diminutive and boxed in ivory or in silver cases, they are suitable for any boudoir or drawing-room.

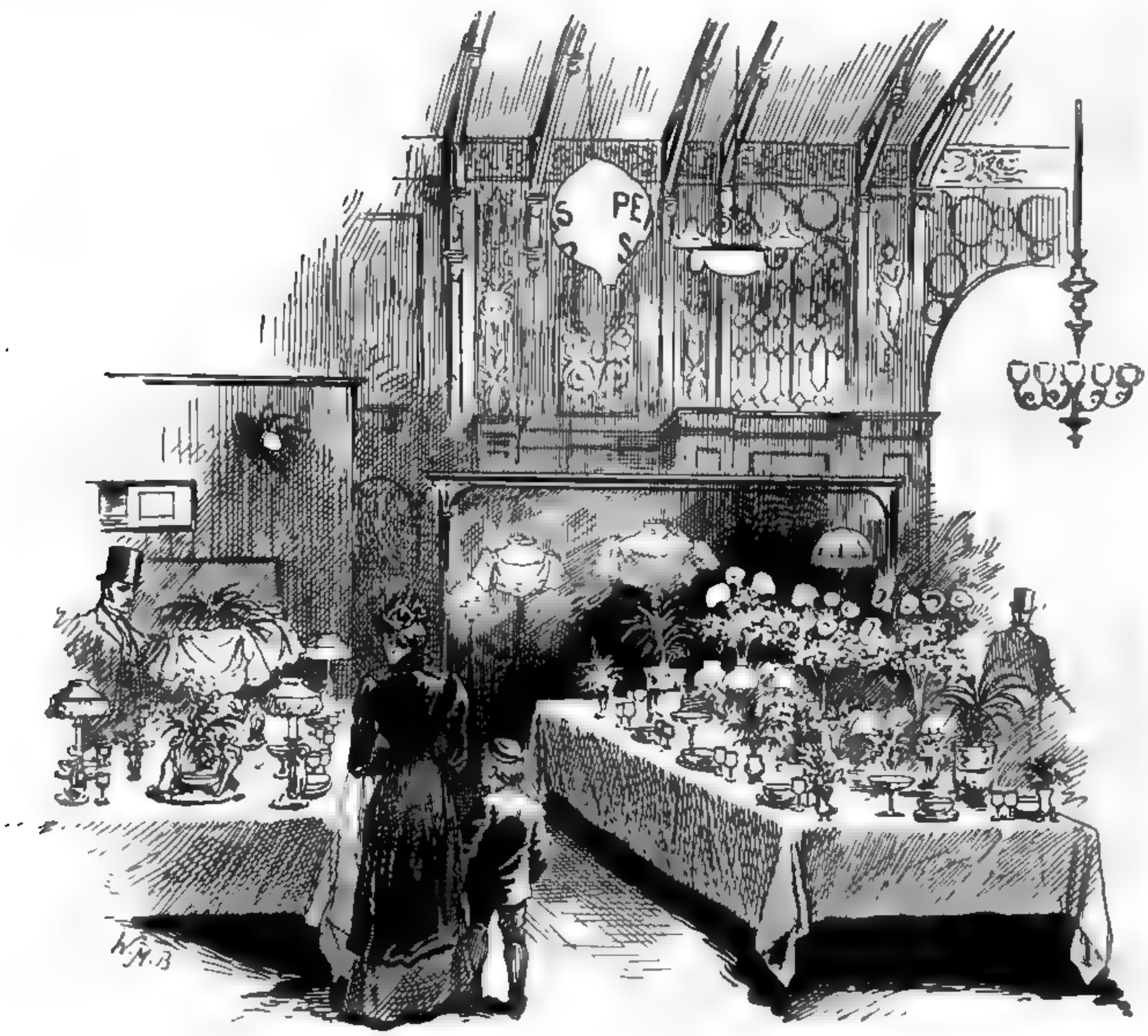
Amongst other fittings of fanciful and delicate design we see swing baskets in light scroll metal for flowers, with radiating arms of simple design, from which are dropped tiny pendant lamps. Single pendants for lobbies and bays are shown, some taking the form of old Venetian cressets of the fifteenth century, others with delicate filagree work

Amongst novelties in switches a noticeable type is shown by **Mr. A. P. Lundberg**, which he terms the "Unique" switch, and those who have seen it will acknowledge the term to be appropriate. The want of a simple, easy-working, and efficient switch, with no working parts to get out of order, has led to the introduction of this pattern. It consists of a key, cover, and base, all of porcelain. The base is provided with a square recess, with a small hole in the centre, in which the centre pin of the key revolves, ensuring in this manner central working of the key in the cover. The key is provided with two helical springs, wound round pins fixed into it. These springs, when the current is "on" make contact with two brass terminal plates, overlapping the side of the square recess, and connected with the circuit; when the current is turned "off" these springs occupy a similar position against two other overlapping brass plates, not in connection with the circuit. When the key is turned in the proper direction—*i.e.*, to the right—these helical springs are gradually wound up on the pins carrying them, and pass over the surfaces of the brass plates. On reaching the edges the power absorbed by the springs comes into effect, and they fly off independently of the motion of the key, producing double independent quick make or quick break of the circuit (according to their initial position) in a manner far preferable to the objectionable "loose key" method, so common in switches now in use. The make and break of the circuit by this method is

practically instantaneous, sparking being thereby reduced to a minimum. It is impossible to hold the key in any position so that sparking can wilfully occur, as is sometimes done, in switches of the "loose key" type, by thoughtless persons or servants. The switch key turns in one direction only, and a simple method is provided to prevent any possibility of the key being turned in the wrong direction. The terminal plates are kept clean by the constant rubbing of the helical springs over their surfaces, but if from dust, salt air, etc., any cleansing should be required, the key can be pulled apart from the base and the parts easily got at. There is absolutely nothing to get out of order and cause inconvenience to the user. The principle of the switch can be applied in modifications for double-pole switches and others.

An ingenious combination fitting, one of the many modifications of the "Unique" switch, is also shown. It consists of a wall socket, portable plug, and switch combined in one fitting. In construction and mode of working it is similar to the "Unique" switch before described, with this difference—the key of the "Unique" switch being replaced by a revolving centre, provided with two tube receptacles for the two contact pins of the portable plug to fit into. A cut-out is also provided if required. The combination of these important parts of an installation reduces the expense incurred by the use of separate fittings to practically the cost of one, less work being also expended in their installation.

An exhibit that will touch electrical engineers in a weak place is that of **Messrs. S. Smith and Sons**, who show a large assortment of non-magnetisable watches. The firm are well known amongst horologists as the only watchmakers who up to a short while ago had ever obtained the highest certificate of excellence in watches from the Kew authorities. We believe the particular watch tested did not vary more than three seconds under any condition in three months. This firm have at the Exhibition, just beside the Machinery Department, a stand where all kinds of watches, unaffected by magnetism, can be seen, from less than the humble guinea up to fifty or more. A continued source of interest to ordinary visitors and electrical engineers alike—for magnetism is no respecter of persons—is an ironclad watch, sticking gracefully to the side of a small dynamo, specially fitted up to show the beauties of this timekeeper, which peacefully ticks away oblivious of "lines of force." The watches are curiously termed "current-resisting," though this is a misnomer of the makers—a current would soon fuse the works—but against magnetism there is no doubt the watch is proof, and a great boon it must be to engineers of central stations or travellers on the underground railway. We are to see a small piece of apparatus for demagnetising ordinary watches at work here, for those who desire, though we are afraid there will not be much chance of a clear escape for an ordinary watch from the Machinery Hall at this Exhibition. The firm hold some very good testimonials from well-known men in electrical work.



A Corner of the Entertainment Court, Crystal Palace.

Our illustration this week is a corner of the Entertainment Court, where Messrs. Phillips and Messrs. Laing, Wharton, and Down combine in producing effective designs for furnishing and lighting dining-rooms. Even Messrs. Laing, Wharton, and Down go so far as to provide the spider on the wall.

THE

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CONTENTS.

TO CORRESPONDENTS.

 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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THE TELEPHONE PROBLEM.

It is understood that the Duke of Marlborough holds a brief for the New Telephone Company, hence his statements in the *New Review* of this month must be taken as those of a partisan. He assumes there will be no contradiction of his sweeping denunciation that "the only line of importance we possess which has been laid in a proper manner is the Paris-London line," and asserts that his clients want "to produce as good a result all over England as is attained on the Paris-London line" ; also "there is no difficulty whatever in accomplishing this result all over England." He contends that "during the ten years of the existence of the monopoly of the telephone patents the business of the telephone in this country has been in the hands of one company, who, for various reasons, have not developed the industry." We are not going to combat these views, except so far as to restrict the condemnation to the London district. If this restriction is not made, we must say that the telephonic progress made elsewhere in two or three districts is as much as could have been expected. With regard to London, there is no good system, there never has been a good system, and under the National Company it may be doubted if ever there can be a good system. We are not even inclined to credit the London administration with empirically feeling its way. The Duke of Marlborough says, "It should be remembered that they have had to work their way from early beginnings, when the principles of the business were little understood." As a matter of fact, the early history of the National Telephone Company is one of company-mongering. The aim was purely Stock Exchange quotations. Any system of working was good enough to run the concern with, and when the men who played ducks and drakes with what ought to have been one of the finest industrial concerns in the land left the concern, their successors, who have worked like Trojans during the past few years, found it a task beyond the powers of men to repair the mistakes made by their predecessors. The action of successive Governments as regards telephony has been almost incomprehensible. No one outside of official circles has ever been able to understand the policy which purchased the telegraph system, maintained that telephony was another form of telegraphy, got the Courts to legally certify it is so, and then permitted private companies to undermine the business of the Postal Telegraph Department. Many of the Government departments are ready to expend money in promising experiments ; and, surely, from the first telephony was promising enough. The expenditure to test it to any extent was not much ; and yet the policy went forth—let private people test it, and we will be satisfied with a royalty. Good ; then if the Government now wishes to get rid of telephony—which is destined, whether the officials admit it or not, to have a very serious effect upon telegraphy—the price must be paid. There are three ways of dealing with the matter in order to obtain as perfect a system as is known. The Government can pass a Bill with as compulsory powers resting in the Board

of Trade as now rest for electric lighting. Why there should be interference on every hand with lighting, and not with telephony, is another matter which is past ordinary mental comprehension. Such powers, however, would compel a riddance of the existing London system in double-quick time. The Government might buy out the existing companies, which, unless under a compulsory purchase, means paying a high price for what is in fact almost valueless. A third way is for the Government to compete with those to whom it has granted licenses. Such competition is hardly to be suggested. It would be unjust to grant a license, allow the spending of money, and then enter into competition. The Duke of Marlborough mentions a fourth course—that the Government own all trunk lines, and permit licensees to work the towns. That plan may be workable; we doubt it. We are quite in accord, however, with the Duke when he states that a much better system can be devised than the one existing, and at a much cheaper rate. It is practically certain that if the New Telephone Company gets its Bill through Parliament and starts to work, the end of the National Telephone system in London is close at hand. The bad system cannot exist in competition with the good. The telephone cannot be said to have lost headway in London solely because of its ineffectiveness. We were compelled to refuse insertion in our last issue to complaints as to the telephone service, because under the existing law we should have had to defend a libel action, even though our correspondent and a dozen others were ready to testify to the truth and accuracy of the assertions made. The best way out of the difficulty is for the Government to do the work itself; the next best way is to support some such company as the New Telephone Company, which has proved its contention in the work done at Manchester, and so aid business and social London to attain the full benefit of one of the most wonderful and most useful inventions of the age.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ELECTRIC TRAMWAYS.

SIR,—In your issue of February 26, you publish a letter from Messrs. Waller and Manville taking exception to my paper on "Electric Tramways on the Overhead or Trolley Wire System."

I am surprised at the tone of Messrs. Waller and Manville's letter, and at the deduction they draw in their concluding paragraph.

As an independent electrical engineer, I have been guided entirely by my judgment and experience in connecting myself with any particular system for traction work, and I, after due thought, selected the company whose system I considered the best, and whose business methods have always commanded my highest admiration.

My paper was written upon the "Overhead or Trolley Wire System," and not upon conduit systems, and I only stated what is a matter of common knowledge in reference to conduits, and with no desire to do more than justice, and to give only statements of facts in reference to all systems.

Messrs. Waller and Manville will be in a much better position and be better able to express such sentiments as are contained in their communication to you, when they have found someone besides themselves with a sufficient belief in their system to put down and work the same. In the meanwhile I can only trust that such a party will soon be found, and that they may have an opportunity of displaying their "wares" in actual service.

Thanking you in anticipation for this space in your valuable paper, I am, with best wishes for electrical systems generally (including conduits)—Yours, etc.,

W. GIBSON CAREY.

35, Parliament-street, S.W., Feb. 29, 1892.

CRYSTAL PALACE EXHIBITION.

SIR,—When next you go to see the Electrical Exhibition at the Crystal Palace you may find some amusement in buying a catalogue, looking it carefully through, and then starting to find some of the exhibits mentioned therein. You can first go and look for the electrical fire engine, then try to find the welding apparatus, then the coal-cutting machine and the rock drill, after that try the "lift," so called, no doubt, on the *lucus a non lucendo* principle, although you may not think the way good. You should then go and see the 100,000 Hedgehogs do their "high volt" transformations; then you had better go in and hear some music beautifully played by Mr. Mann's talented orchestra. This will relieve your mind, and give you an appetite for a good dinner at Bertram's *table d'hôte* before undertaking the dismal railway journey home.—Yours, etc. X.

P.S.—In my last week's letter the word "choir" should be "chair."

A DESCRIPTION AND COMPARISON OF THE METHODS OF ELECTRIC LIGHTING AT PRESENT IN USE IN LONDON.*

BY ALEXANDER B. W. KENNEDY, F.R.S., M.I.C.E., ETC.

(Continued from page 186.)

A perfect transformer ought always to give in its secondary circuit exactly the same amount of energy as that which has passed through its primary circuit. No actual transformer does this, but the efficiency of good transformers at their full load is very high—often over 90 per cent. But the full load of a house transformer corresponds to the current necessary for all the lights in the house; the transformer must of necessity be large enough to allow for this. All the lights in a house, however, are not on at once half-a-dozen times in the year; in general the maximum load in a house is less than half its full number of lamps; its average load not more than a quarter, and, of course, for many hours out of every 24 no lamps are burning at all, so that the load is zero. Unfortunately, the losses in the transformer continue all the 24 hours, whether or not there is any current passing through the secondary coil. These losses are more or less proportional to the full load for which the transformer is designed, and, taking all together, they are most serious. Such authentic statistics as I have been able to obtain show that the consumption of coal in a central station per unit passed through customers' meters is at least twice as great with the high-tension companies as with the low-tension, the figures being 17lb. to 20lb. with the one, 8lb. to 10lb. with the other. The greater part of this difference is probably due to the transformer losses. In fact, a company which has 500 transformers in its customers' houses is practically keeping as many small fires burning day and night in as many cellars at its own expense. Of course, whatever these losses may be, they do not affect the meter readings, and the customer has not got to pay for them. To remove these losses a change in method is now proposed, and I believe the London Company, at least, are taking active steps in this direction. The proposal is to remove the transformer from the customers' houses altogether, and to concentrate the transforming plant at

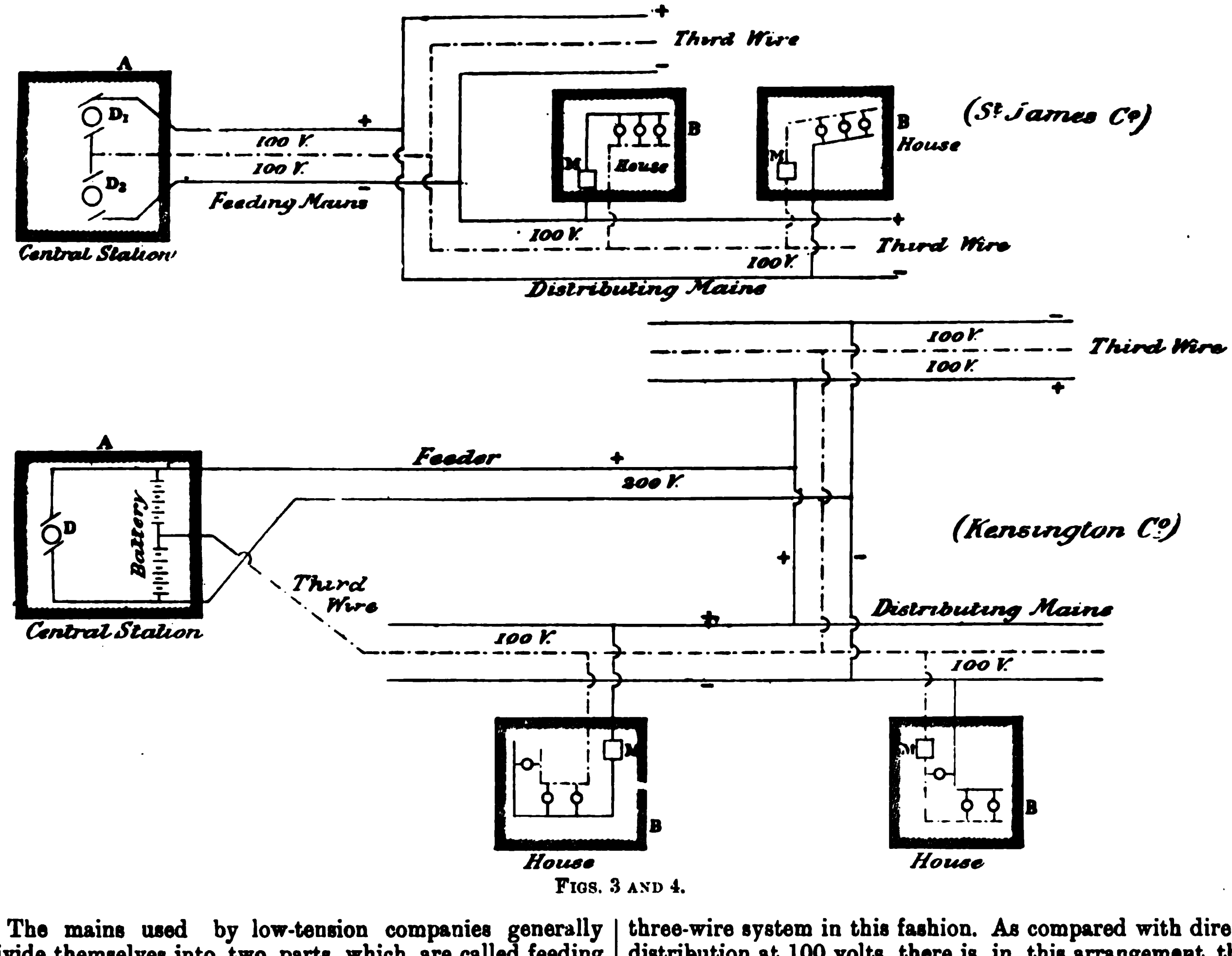
* Reprinted from the *Transactions* of the Royal Scottish Society of Arts, vol. xiii., part 1. Read May 11, 1891.

certain sub-stations, where the load will never be zero and where the number of transformers in use can be altered from hour to hour as the load varies, so that the instruments actually in use can always be worked with fair economy. This change, the wisdom of which I do not doubt, and which is being advocated most strongly by some of our best engineers, is a very far-reaching one indeed, although it seems at first to affect only a matter of detail. For, in reality, it necessitates giving up at once three-quarters of the high-tension mains, and laying new low-tension mains suitable for 100 volts pressure, from each sub-station over the whole district, exactly as in a low-tension system. If this has to be done, it is obvious that the greater part of the saving in first cost due to the use of high-tension mains disappears at once, and, as the system of "banking" transformers is as yet very little practically known, it remains to be seen to what extent it attains in practice the results expected of it. I understand that this is the system which it is proposed to use in the City of London itself, by the new company which has just been started for the purpose of lighting that district.

The low-tension companies try, as far as possible, to use bare copper strip carried on porcelain or glass insulators. This strip is enclosed in concrete culverts or iron conduits. The advantage of its use is clear, when it is remembered that the cost of the ordinary indiarubber insulation of any cable is considerably greater than the actual cost of the copper insulated. The use of bare copper, properly insulated, is quite safe up to a pressure of about 200 volts, but, of course, is impracticable with high pressures.

The systems adopted by the low-tension companies in London vary somewhat among themselves, but have certain points in common. All of them use continuous currents, and all of them but one are schemed to generate electric energy at a pressure of about 200 volts (not 100), so as to save to this extent in their mains. The distribution to houses at 100 volts, without the use of transformers or any other apparatus, is effected by a subdivision of the 200 volts into two sections or parallels of 100 volts each (by the use of what is called a third wire), and dividing the consumers, as evenly as may be, between the two sections.

Fig. 3 shows the way in which lights can be put on a



FIGS. 3 AND 4.

The mains used by low-tension companies generally divide themselves into two parts, which are called feeding and distributing mains respectively. The latter are the mains to which the house services are directly attached, and which cover the whole of the streets in the district. They are common to all systems of low-tension distribution, and will have to be used equally by alternating-current systems, if these adopt transformer sub-stations in the way just alluded to. The cost of the distributing mains is considerably very much more than half the total cost of the mains—a point to be kept in view. Feeders or feeding mains are lines radiating directly from the central station, and carrying current from it to certain fixed points, called feeding points, where they join the distributing mains. These feeders are the mains which have the largest section of copper, but they are few in number, and their total length is not nearly so great as that of the distributing mains. In a modified high-tension system, such as mentioned above, each feeder would be replaced by a line of very much smaller sectional area of copper, having a sub-station with transformers at the point where it joins the distributing mains.

three-wire system in this fashion. As compared with direct distribution at 100 volts, there is in this arrangement the very great economy that the amount of energy carried by means of a given section of copper is double, while the difficulties of insulation are not considerably increased. The three-wire system is shown in Fig. 3 as it is carried out by the St. James's Company. Two dynamos, D and D_2, are connected "in series"—that is to say, the positive pole of one to the negative pole of the next. Each dynamo generates current at 100 volts pressure. The difference in pressure, therefore, between the positive and negative mains is 200 volts. A middle, or third wire (shown by a dotted line in all the figures), is connected between the dynamos, and is carried round the circuit, the houses, B B, etc., being placed alternately on the one and the other parallel (as sketched) so that the pressure in the house is never more than 100 volts. If an exactly equal number of lamps was alight at any time on each of the two parallels, no current would pass through the third wire. But, under ordinary circumstances, the number of lamps on the two parallels is not exactly equal, and one of the dynamos will have to work a little harder than the other to make up the difference.

The use of storage batteries or accumulators is possible only upon a continuous-current system. As to the use and economy, or otherwise, of batteries, there has been very warm controversy. In London, Mr. R. E. Crompton, the engineer of the Kensington and Knightsbridge Company, has always been the leading advocate for their use, and has succeeded in very greatly improving their design. I am using them in my own district, and, while admitting that it is possible to exaggerate their advantages, I find them so useful that I could on no account be without them. The St. James's Company, on the other hand, whose conditions of working are no doubt somewhat special, scarcely use them at all, and have been very successful without them. My plan in the work of the Westminster Company has been to use them as a stand-by and regulator during work, and for taking up the whole load during the small hours of the morning, or at other times of minimum demand, thus allowing the station to be entirely "shut down." This is a matter of which the immense advantage and convenience probably appeals more to the engineer than to the consumer. I pass from 5 to 6 per cent. of the whole of the current generated through the batteries, and on that fraction I lose, on account of the imperfect action of the batteries, 15 or 16 per cent. measured in energy. I therefore pay something under 1 per cent. in total efficiency as the price for the convenience of using batteries, even supposing that they do not (as I believe they do) very much more than make up for this, by obviating the necessity for working boilers and engines at all during hours of minimum demand. The system used, and I believe originated, by Mr. Crompton is sketched in Fig. 4. It will be seen that the batteries are placed in parallel with the dynamos, and the third wire connected to the middle of the battery only, and not to the dynamos. Instead of two dynames in series, one dynamo only is used, and it generates current at 200 instead of at 100 volts.

(To be continued.)

DESIGN AND CONSTRUCTION OF DYNAMOS.*

BY T. ROOKE.

In considering the design and construction of dynamos, let us devote our attention first to continuous-current dynamos, and later we will pass on to consider some of the more prominent alternate-current machines that have of late come to the front in connection with the electrical transmission of energy.

First, then, the design of a continuous-current dynamo resolves itself into the treatment of two factors—the magnetic circuit and the electric circuit—and each of these may be considered to a certain extent separately. The commercial dynamo is always made with electromagnets. Sometimes they are self-excited, and at other times, such as

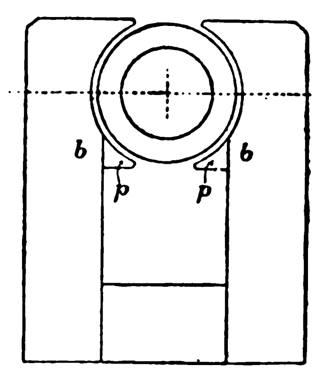


FIG. 1.

with alternate-current dynamos or high-pressure continuous-current machines, they are separately excited. The iron in a dynamo which constitutes the magnetic circuit is made up of four parts—the two limbs, the yoke, and the armature core; besides these, and the most important of all, is the air gap. These parts can easily be seen from Figs. 1, 2, 3, 4, and 5, which represent various forms of arrangement. These iron parts have first to be designed to give the highest efficiency with the least weight, and often space has to be taken into account as well. In the early

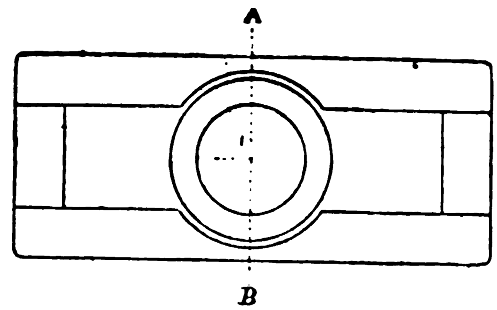


FIG. 2.

days of dynamo designing the cross-section of the armature core in cylinder machines was very small, in proportion to that of the field magnets, the copper in the armature was

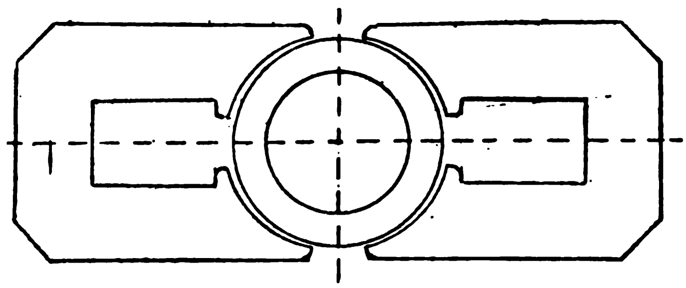


FIG. 3.

excessive, and the air gap large. Increasing the iron and decreasing the copper on the armature was found to improve the machine, it kept cooler, and did not require so

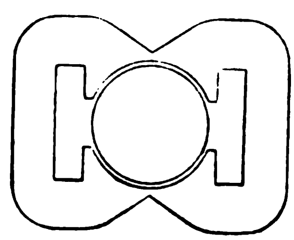


FIG. 4.

much magnetising force to give the same output. At present with most makers the ratio of the iron cross-section in the armature to that in the field magnets is between 1 to $\frac{3}{4}$ and 1 to 1.

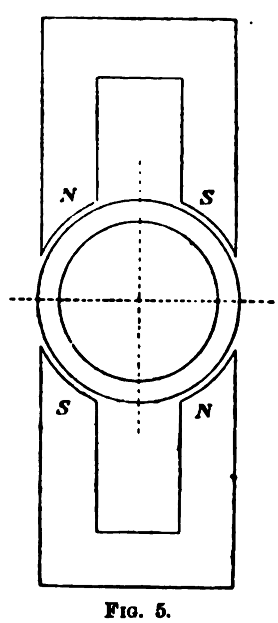


FIG. 5.

The magnetic induction at which machines usually work varies according to the quality of the iron used, but is somewhere about 15,000 lines per square centimetre in wrought-iron field magnets, which are pretty well saturated.

* Paper read before the Students of the Institute of Civil Engineers at Birmingham, Feb. 4th, 1892.

The armature is slightly under-saturated in order to keep the loss from hysteresis as low as possible. The air gap must be kept as small as is mechanically possible, for, as will be seen, it causes the greatest amount of magnetic resistance to the passage of the lines of force. For this reason, in large machines it becomes best only to wind one layer of wire on the armature; small machines have frequently two layers, but this depends entirely on the E.M.F. required.

Bearing in mind the best proportion of the armature to the field magnets, and the necessity of keeping the air gap small, the first condition to be fulfilled is that

$$E = \frac{n.C.N}{10^8}.$$

E is the E.M.F. in volts; N is the total magnetic induction in the armature, or the total useful magnetic induction; n is the number of revolutions of the armature per second; C the number of conductors counted all round the outside of the armature; and 10^8 is the ratio of the practical unit to the absolute unit of E.M.F. With these requirements it is not difficult to decide on the sectional area of the different parts of the magnetic circuit.

As regards the yoke which connects the limbs of the magnet, it is not of great consequence as to its exact shape, nor yet whether it is of cast or wrought iron, it being merely necessary to have it large enough to conduct the lines of force without throttling them; and comparing the induction curves for cast and wrought iron, Fig. 6, it will be seen that the area of the yoke, if cast iron is used, must be at least two and a half times that of wrought iron.

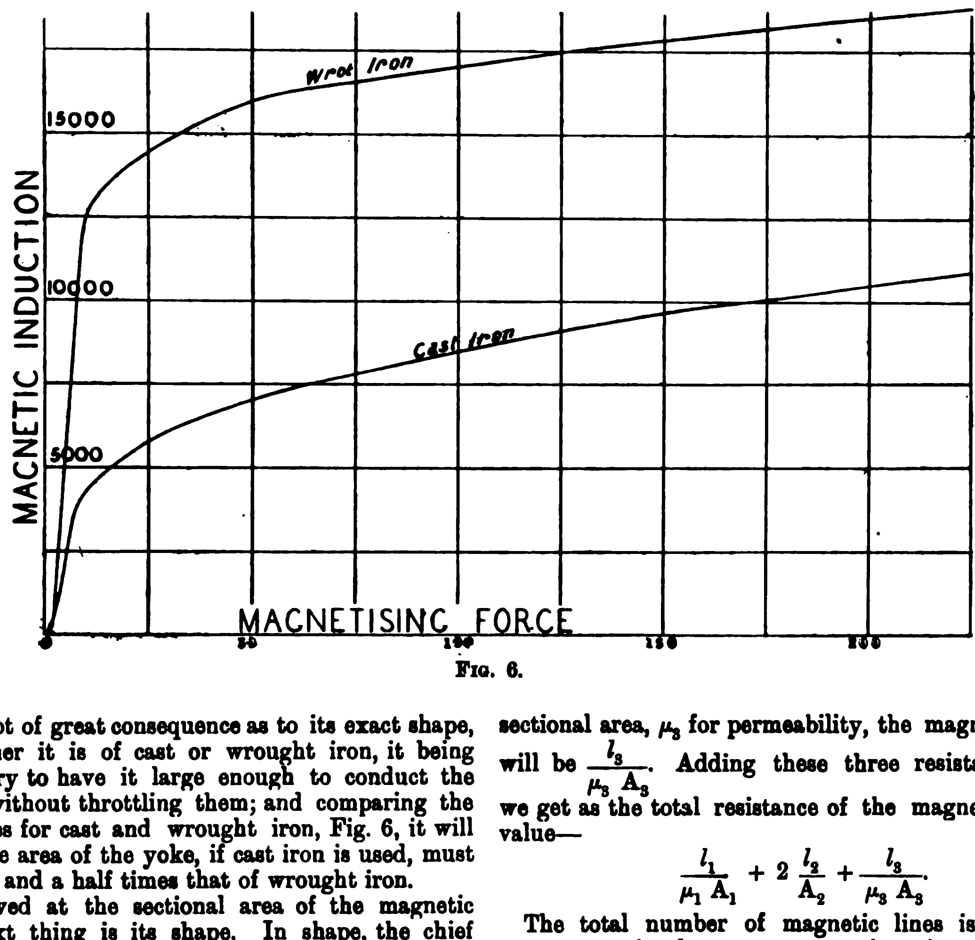


Fig. 6.

Having arrived at the sectional area of the magnetic circuit, the next thing is its shape. In shape, the chief objects to attain are cheapness of construction and convenience in winding, keeping the magnetic circuit always as short as possible. For cheapness, small dynamos are often built with wrought-iron cylinder limbs and cast-iron yoke and pole-pieces. For large machines a cylinder becomes awkward, as it takes up so much more room, and the pole-pieces would have to be so massive, so the whole magnet limb is built up of iron rails, or forged in one piece and made rectangular in section. The number of poles is generally limited to two for ordinary machines; four are sometimes used, principally for large machines giving heavy currents, although even more have been used.

Let us proceed to the winding. The wires on the armature are calculated from the formula already given, $E = \frac{n\,C\,N}{10^8}$. The most difficult part of the winding to calculate, however, is that on the magnets, and it is done as follows.

A generally applicable formula has been given by Dr. Hopkinson. Let N be the total magnetic induction through the armature necessary to induce the E.M.F., E, at the specified speed, n. The magnetising power, or magnetomotive force, of i amperes passing S times round a magnetic conductor is $4\pi S i \div 10$. N being in C.G.S. units, i has to be divided by 10, as it is in practical units. The magnetic resistance to lines of force is proportional to the length of their path and inversely proportional to the sectional area of the circuit, and the permeability of the iron. Suppose, then, the three parts of the magnetic circuit l_1 = average length of lines of force in the armature core, of which the sectional area is A_1, and the permeability μ. This part of the magnetic circuit will have a resistance of $\frac{l_1}{\mu_1 A_1}$. Similarly, for the two air gaps, if the length of path across each from iron to iron be called l_2, and the area of each polar surface A_2, the magnetic resistance these two offer will be $2\frac{l_2}{A_2}$, μ being for all non-magnetic substances equal to 1. Similarly, for the iron field magnets writing l_3 for length of path through iron from pole to pole, A_3 for sectional area, μ_3 for permeability, the magnetic resistance will be $\frac{l_3}{\mu_3 A_3}$. Adding these three resistances together, we get as the total resistance of the magnetic circuit the value—

$$\frac{l_1}{\mu_1 A_1} + 2\frac{l_2}{A_2} + \frac{l_3}{\mu_3 A_3}.$$

The total number of magnetic lines is equal to the magneto-motive force over magnetic resistance, or

$$N = \frac{4\pi S i}{10\left\{\frac{l_1}{\mu_1 A_1} + 2\frac{l_2}{A_2} + \frac{l_3}{\mu_3 A_3}\right\}}.$$

Dr. Hopkinson expressed this formula a little more generally—as follows:

$$\frac{4\pi S i}{10} = l_1 \int\left(\frac{N}{A_1}\right) + 2\,l_2\left(\frac{N}{A_2}\right) + l_3 \int\left(\frac{N}{A_3}\right).$$

For each part of the magnetic circuit he plotted a curve representing each of these functions, and from them he then plotted a resultant curve which was the characteristic of the magnetic circuit.

Having thus got a formula or curve for calculating the exciting power necessary for the field magnets of a dynamo, we must next introduce a coefficient of leakage or a correction to allow for the leakage of lines of force. This cannot be calculated beforehand with any accuracy for a

new type of machine, but must be obtained from experiment—a list of values is given for various well-known types which are most commonly met with.

CORRECTIONS FOR LEAKAGE OF LINES OF FORCE.

Type of Dynamo.	Value of v^2.
Edison-Hopkinson	1·32
Siemens	1·30
Manchester	1·49

Owing to the spreading of the induction, it is necessary to assume the air gap as having an extension beyond the polar area equal to ·8 of the distance between the armature core and the polar surfaces. The formula thus corrected becomes

$$\frac{4\pi S i}{10} = l \int \left(\frac{N}{A}\right) + 1{\cdot}6\, l \frac{N}{A_1} + l_2 \int \left(\frac{v_2 N}{A_2}\right) + \text{etc.}$$

$$\text{or} \quad \frac{4\pi S i}{10} = N\left(\frac{l_1}{\mu_1 A_1}\right) + 1{\cdot}6 \frac{l_2}{A_2} + \left(\frac{v_2\, l_3}{\mu_3 A_3}\right)$$

Having calculated thus as nearly as possible the number of ampere-turns to be wound on to the magnets of a machine, the resistance of the magnet coils and the current flowing in them is calculated in accordance with the well-known formula $C = \frac{E}{R}$.

The next thing we come to is ventilation and cooling, both of armature and magnets, for a certain amount of energy must always be lost in a machine on account of its electrical resistance, and this energy is converted into heat and must be dissipated, especially as the resistance of copper is increased rapidly by an increase of temperature.

This area for dissipating heat varies considerably, as do most other things, in different types of machines by different makers, and besides this the temperature of the place in which the dynamo has to work must be taken into account, if any fixed rule is to be given. Mr. Kapp gives, with a surface speed of 2,000′ to 3,000′ per minute, cooling surface ought to be ·8 to 1 square inch for every watt transformed into heat in the armature wires; magnets 1·5 to 1·8 square inch, but this rule cannot be fixed within considerable limits for the reasons given above. These rules are the nearest possible approximation for calculating beforehand the proper dimensions of a dynamo with a given output, but it must not be forgotten that they are only an approximation, although a close enough one for practical use. A dynamo having been completed, its performance should be recorded in such a manner that we shall be able to tell at a glance what a machine of similar carcase dimensions will give under any circumstances. First, the machine is run on open circuit, and the relation between the ampere-turns on the magnets and the E.M.F. established. Whilst running at the same speed take the greatest possible current from the armature, and, keeping this constant, take observations of the magnetising force and E.M.F., the field being weakened down step by step until it is just possible, by adjustment of the brushes, to run without sparking. Repeat the experiment for a less current in the armature; then for a smaller still, until there is a series of curves representing the relation between the magnetising force and the E.M.F. for several different values of the ampere-turns on the armature. This load diagram will tell us everything we wish to know about the magnetic circuit of a machine having these particular dimensions, and about the interference of the armature with the field circuit; it tells us the ampere-turns required for any induction on open circuit, or, in other words, the magnetising force required for the shunt only; if the machine is to be compounded, it tells us how many ampere-turns must be added to raise the E.M.F. by a required amount with any current flowing, or to compensate any armature load; it tells us how we can over-compound the machine; and lastly, just how far we can weaken the field for any load, without producing sparking.

Proceeding now to the actual construction of dynamos, let us first consider the most important part—namely, the armature. All continuous-current dynamos of practical importance at the present moment can be grouped under three headings: 1. Dynamos with drum armatures wound on the Hefner alternate principle. 2. Dynamos with cylindrical armatures wound on the Gramme principle. 3. Dynamos with disc armatures wound on the Schuckert principle.

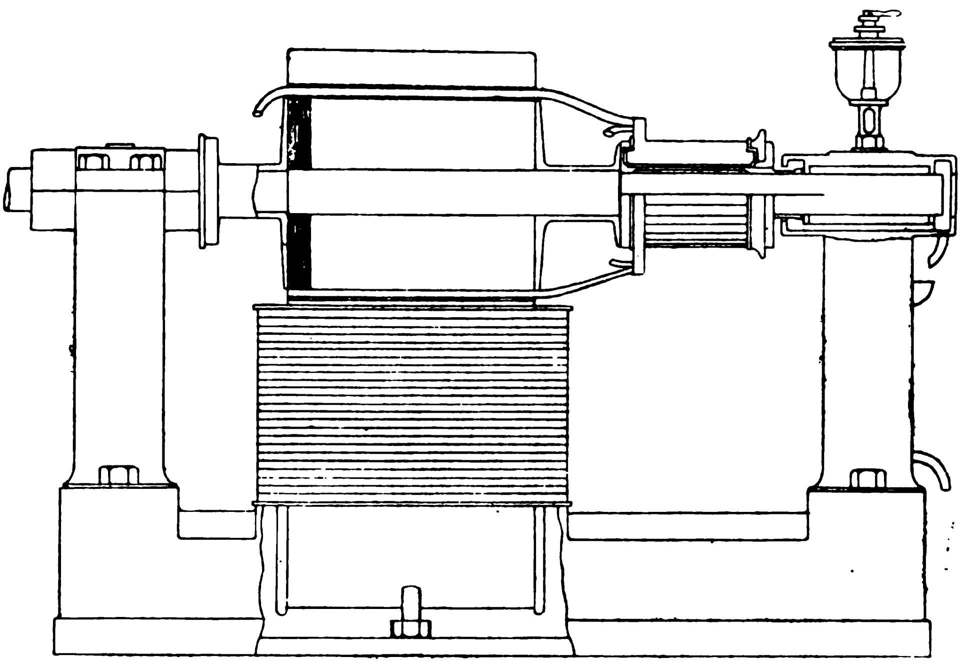


FIG. 7.—Elwell-Parker Dynamo.

The first type is represented by many makers, such as Edison, Siemens, the Electrical Construction Corporation, etc. The second type used to be represented by the largest number, but many of them now build the first type. The third type is made by the Brush Company and the Gulcher Company. From a scientific point of view all these machines, though of such wide variety of design and general arrangement, can be treated in a similar manner, and in all cases the E.M.F. in the armature is expressed by the formula $E = \frac{n\,C\,N}{10^8}$. The complication arises in determining the coefficients of leakage, depending on the shape of the field magnets. The great object in most of these armatures is to get the greatest E.M.F. generated with the least length of copper wire. Some parts of the armature are useless so far as this goes, such as the inside wires of a Gramme machine, and the end winding of a drum armature, and in the early days of dynamo design this gave rise to endless complicated forms of field magnets. It is, however, evident that all armatures are not alike in this respect. Mr. Kapp gives the following figures: The length of wire per volt generated in different armatures having the same magnetic induction

per square centimetre of armature core is, for drum 6·5in. to 16·4in., cylinder 21·8in. to 26·1in., disc (square or circular core) 26·3in. The above table shows the great superiority of the drum over any other armature. The long cylinder comes next, but is not generally employed in modern machines on account of vibration in the spindle. The tendency is to use short cores in order to reduce the distance between the bearings. Cores of equal length and diameter are often used. The flat ring which was extensively used in the early days of disc armatures is still worse as regards the length of wire required to wind it, requiring three times as much wire as the short cylinder. At one time, a very narrow and deep ring was considered the best form to be given to the core of a Gramme armature, as thereby a great expansion of polar surface could be obtained, thus bringing the whole of the wire under the direct influence of the magnets. Experience has shown, however, that this is a fallacy. For continuous-current machines used for incandescent lighting and plating, drum armatures are almost universally used, now that it is possible to ensure good insulation, which was at first one of the difficulties with this type of armature. Machines such as the Thomson-Houston and Brush are used chiefly for running arc lamps in series, as they are more easily regulated as constant-current machines. They are unique dynamos in construction, which it is hardly necessary to describe more fully here.

The construction of armatures is as follows: The old Gramme was made up of either very thin circular iron washers insulated from one another generally by varnish or paper, or else it was made up of a coil of charcoal iron wire wound on a former. This former was taken away, the iron wire core insulated by winding on tape, which was then varnished over; the coils were then wound on and the whole connected, and mounted on the driving shaft on a block of wood—the driving power was transmitted from the shaft simply by friction, and for small dynamos this was sufficient. To prevent the external wires from flying out when the armature was driven at a high speed, they were bound in by bands of brass wire passed round the armature, and insulated from the conductors by mica. Elwell-Parker Gramme armatures used to be built up of a wire core wound directly on to a brass spider, or framework of radial arms; to keep the core true, a light cut was taken over it after every two or three layers of wire had been wound on. The conductor on these armatures was driven partly by friction, partly by the coils pressing on the sides of the radial arms. It was usual to put only one layer of conductors on these armatures. Of course, there are modifications in the building of armatures by different makers; but we have only space to consider the main features of each type.

The old Pacinotti armature, which is a hollow cylinder like the Gramme, was always built of sheets of charcoal iron, insulated from one another; it has on its surface projecting teeth. The object of these teeth was partly to diminish the magnetic resistance of the air gap, and partly to act as drivers to the wire coils. It was found, however, that with the diminished clearance between the projections and polar surfaces the magnetic induction exerted by the projections on the polar surfaces absorbed a considerable amount of power in heating the pole-pieces with local currents, and no amount of subdivision could get over it. The ordinary drum armature is built up of a lot of thin discs of charcoal iron insulated from one another by varnish, paint, or paper. Sometimes they are fitted on to the square shaft, at other times they are keyed on to the shaft, and are then pressed together between end plates till they are fairly well solid, the end plates being made of bronze, or non-magnetic metal. The armature core is then turned up true with a very sharp tool, so as not to burr the edges of the thin plates, and the outside is insulated with cloth, varnish, and mica, and the coils are then wound on the armature, sometimes in one layer, sometimes in two. In a drum-wound armature with only one layer of wire the full potential of the dynamo will be between every two adjacent wires, and special care must therefore be paid to their complete insulation from one another. With two layers of wire on the armature, as in high-tension machines, the full potential of the machine is between the two layers, which are more easily insulated by a sheet of cloth and mica strips. These are close-coil armatures—that is, they have all their coils in series with one another, forming a closed circuit. Thomson-Houston and Brush machines are the two principal open-coil armatures. The shape and construction of magnets has already been discussed under the treatment of the magnetic circuit. The coils for magnetising them are wound on bobbins and slipped on. Sometimes, but not often, the coils are wound directly on to the magnet limbs, in which case they cannot be taken off except by unwinding. The commutator, or collector, is generally made as shown in the section, or is some slight modification of it. A number of copper bars having lugs left at each end are milled up so as to fit together and form a hollow cylinder. These bars are held together by insulated iron rings passed over the lugs, and are insulated from one another by mica. The whole is insulated and mounted on a cast-iron core, which is keyed on to the shaft. Bearings are generally of white metal. Brushes are held on insulated pillars, and their pressure on the commutator is regulated by means of a spring, the pressure being just sufficient to ensure good contact. They are made of pure copper. Either a number of thin sheets are laid together and one end of the layer soldered up, or they may be made of a number of copper wires soldered at one end, or, what is perhaps best for a good dynamo, they may be made of gauze. The advantage of a gauze brush is that it does not cut the commutator at all, like wire or plate brushes; the disadvantage is that on a bad dynamo which sparks a lot, the gauze rapidly wears away. In order to avoid sparking, it is necessary to adjust the brushes to the load of a machine, and this is generally done by means of a rocker fixed to the pedestal or bearing, and capable of being turned through an arc round the commutator.

Let us pass on to alternate-current dynamos. These have lately come forward very prominently in the distribution of power at a high tension, and its conversion to a low tension by means of the alternate-current transformer. In these machines alternate currents are induced in the armature coils by causing the amount of magnetic induction through them to alternately increase and decrease. Most frequently there is not simply an alternate increase and decrease, but a rapid reversal in the direction of the magnetic induction. In some of these machines, as in the majority of continuous-current dynamos, the armature part rotates whilst the field magnet part stands still. In others, however, the armature part—that is to say, the part from which the alternating current is to be obtained—is a fixture, whilst the field magnets are made to rotate. In a third class of machine, both armature part and field-magnet part are fixed, the amount of magnetic induction passing from the latter through the former being caused to vary or alternate in direction by the rotation of appropriate pieces of iron. In the older machines, the field magnets were either of steel permanently magnetised, or else electro-magnets separately excited. About 1869 began the practice of making these machines self-exciting by diverting a small current from one or more of the armature coils separated from the rest, and this current was rectified or made continuous by being passed through a crown commutator, and thence to the field magnets. These crown commutators are not generally used now, it being more convenient either to mount a small continuous-current armature on the shaft of the alternator, and thus obtain the exciting current. If the alternator runs at too low a speed for this, the exciter is driven by a belt from an exciter pulley fixed on the alternator shaft. For collecting the alternating main current of the dynamo, extremely simple means are required. In most machines where the armature is fixed, two terminals only are required; in machines with revolving armatures sliding connections only are required. Hence there is no sparking, and no adjustment of brushes with a varying load—in fact, one of the most expensive parts of a dynamo is rendered unnecessary. As it is requisite in alternate-current working to have many alternations in every second, and as mechanical considerations forbid very high speeds, it is the general practice to make this class of machines multipolar, with a considerable number of poles of alternate polarity arranged symmetrically

around a common centre. The number of complete alternations per minute in machines of different systems varies considerably from 2,500 to 12,000 or more, but about 6,000 is mostly used. The number of poles, Fig. 8, also varies from 12 to 32 or more, depending, of course, on the specified speed and number of complete periods per minute. There are two ways of coupling up the coils of alternate-current dynamos. For lighting incandescent lamps from parallel mains it is usual to connect the coils in parallel. This is low-tension distribution, such as is used at Paddington. For high-tension transformer work the armature coils are connected up in series.

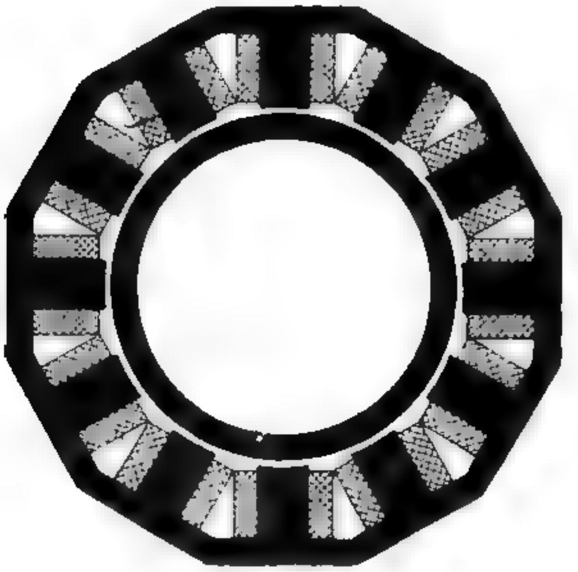


FIG. 8

With these brief remarks on alternators we must end. The mathematical treatment might be extended, as also losses from hysteresis, running in parallel and multiphase dynamos, but time does not allow.

ELECTRIC TRAMWAYS ON THE OVERHEAD OR TROLLEY WIRE SYSTEM.*

BY W. GIBSON CAREY.

(Concluded from page 208.)

In the development of the electric tramway no part presented to the pioneers difficulties comparable to those encountered in the operation of the rolling-stock, and changes in the construction of every detail have been constantly made as experience pointed out opportunities for improvements in the mechanical and electrical details. It was soon found that the methods of supporting the car bodies which were employed in animal traction would not do for electric service, and specially-designed trucks, upon which the motors were carried beneath the car bodies, were soon brought out. The matter of trucks is one of greater moment than would appear at first sight, for upon proper design and workmanship in the truck depends the smooth and safe operation of the car, while the greatest possible simplicity and accessibility of all parts is necessary for ready examination and economical repair in case of accident. This simplicity, however, is not so easily accomplished as might be supposed. The electric car has nothing to steady it like the constant pull of the horses on the drawbar in animal traction, and the fore and aft oscillation is prevented by ingenious designs in a score of trucks upon the market to-day. Out of these, however, there are scarcely half-a-dozen which are not so complex in construction that the smallest accident will necessitate an enormous amount of labour in order to get at and repair some trifling part. A truck that has to be entirely pulled to pieces in order to replace a pair of wheels will not pay in the long run, however perfect it may be in preventing oscillation and affording smooth running.

In crowded cities, on lines upon which the traffic is very large, and more or less constant, the use of very long cars is often found advisable, and in such cases bogie trucks must be used. There are, however, several considerations which qualify the advisability of very large cars. While double carrying capacity can be obtained at the expenditure of about 50 per cent. more power, the expense of hauling round very large cars nearly empty, when the traffic is light, will in most cases more than counterbalance the advantages to be gained, and on a large majority of roads a small car running during busy hours on a very quick headway is preferable. One decided disadvantage which the large car on bogie trucks possesses is the smaller proportionate weight available for the purpose of traction which it possesses. It is not practicable to gear motors to all four axles, and the universal practice is to drive such cars by two motors, each being geared to one axle of each truck, so that only half the total weight of the car is available for traction. One manufacturer has brought out a most excellent six-wheel truck with a very long wheel base, in which the axles automatically assume a position radial to any curve. In this truck almost the entire weight of the car is supported on the driving wheels, and the chief objection to the eight-wheel car obviated.

The first attempts at driving cars by electricity were made with motors mounted on the platforms and geared to the axles by means of sprocket chains. This clumsy contrivance was, however, speedily superseded by motors supported directly upon the axles and upon a flexible suspension from the truck, entirely independent of the car body. Spur gearing was used, by which the speed was reduced from about 1,000 revolutions at the armature shaft to 100 at the car axle. The limited space under the car precluded the use of large gears, and the reduction of ten to one was accomplished in two steps by means of an intermediate shaft. To-day single-reduction motors have in turn supplanted these, and the solution of the problem of gearless motors, with armatures mounted directly upon the car axles, is, perhaps, a question of the very near future. Motors of this class are, indeed, in operation to-day, but it is very questionable whether their development has reached a point at which any advantage can be gained by their adoption. The total efficiencies of the double and single reduction motors appear to be about the same, the enormous economy effected by the use of the latter being due chiefly to reduced wear. The single-reduction gears running in oil in a dust-tight casing are kept thoroughly lubricated, and are protected from the grit and flyings which formerly made the renewal of gears one of the most important items in the repair account of electric roads. Smoothless and more noiseless operation has also been effected, and it cannot be doubted that single-reduction gearing has been one of the longest steps in the direction of the perfect motor that has been made in the history of its development. Freedom from sparking under wide variations of load and change of direction of rotation is secured by making the field magnets very powerful in proportion to the armature. The output is, of course, smaller in proportion to the weight than if the magnetising effect of the armature coils were relatively greater, but in that the slight increase of weight gives better traction, this is of small importance, and as the relatively weak magnetisation due to the armature coils produces no distortion of the magnetic field, we can use fixed brushes, set radially to the commutator, which are sparkless under all conditions. The motors being series-wound, the speed with a given number of turns in the field coils, is directly dependent upon the applied E.M.F. and the resistance of the circuit, and can, therefore, be varied at will by the introduction of a graduated resistance in series with the motor. This resistance comes very little into play, but is necessary in order to avoid a jerky movement in starting. After the dead resistance is entirely thrown out of the circuit, the speed can be further increased by cutting out part of the field coils which are wound in section, the bights of the coils being led to a switch operated by the same mechanism that controls the rheostat. This weakening of the field must not, however, be so great as to allow a distortion of the field by the reaction of the armature current, or destructive sparking will ensue.

For most city work it has been found advisable to use

* Paper read before the Royal Engineers.

motors of about 30 h.p. capacity on each car. This is usually divided between two motors of 15 h.p. capacity, one being geared to each axle. In this way the entire weight of the four-wheeled car is available for the purpose of traction, and in case of an accident to one motor the car can be run into the depôt with the other, instead of being disabled, as would be the case if a single motor were used. The motors which are coupled in parallel with each other are reversed by reversing the direction of the current in the armatures. This has generally been accomplished by leading the current first to the fields of the two motors in multiple with each other, and hence through a reversing switch to the armatures, which are also in multiple with each other. The current in the fields of the two motors will, of course, with such a system of connections, be inversely proportional to the ohmic resistance of the field coils, so that an equal distribution of current between the fields can easily be secured by carefully winding them to the same resistance. As, however, these field currents are again brought together into one at the reversing switch, the currents in the armatures will depend not only on the respective ohmic resistance of the armatures, but upon the counter E.M.F.'s generated in them. Owing to differences in the iron employed in construction of the motors, it is difficult to exactly balance those, and the only practicable way of equally distributing the load between the two motors is by the employment of two reversing switches, so that the two motor circuits are entirely separate and distinct from each other. It is only by the most careful attention to such details as these that smooth and economical operation can be secured.

The current is collected from the trolley wire by means of a grooved gunmetal trolley, carried upon a trolley bar, mounted upon the roof of each car. This bar has a universal joint at its base, which allows the trolley bar to move in any direction, while springs acting upon a cam arrangement of peculiar design tend to keep the bar in a perpendicular position. The design of this arrangement is such that the upward pressure of the bar is equal whatever the tension on the springs, so that the trolley is always kept firmly pressed against the trolley wire, in spite of any variation in the height of the latter, and the flexibility of the universal joint allows it to follow any deviation of the wire away from an exact central position over the track. In the circuit between the trolley stand and the motors are interposed a fuse cut-out, which protects the motors and the wiring in case of an accidental short circuit, a lightning arrester, and the variable resistance, which is usually of iron, the rheostat being insulated throughout with mica to avoid danger from overheating. The current after passing through the rheostat is taken to the motors, and from thence through the wheels to the track and supplementary wiring, by which the circuit is completed back to the generator.

The use of a lightning arrester both on the cars and at the power station removes one very fruitful source of accidents—the long line of trolley wire, especially in country districts, being exceedingly liable to be struck by lightning, and unless some path can be provided for the escape of the discharge to earth, disastrous results to generators or motors are almost certain to follow.

Such objections as have been raised to overhead electric tramways have been made purely from a sociological point of view, and experience has invariably led to the modification or entire withdrawal of these. To the public is offers cleaner and less obstructed streets, and less wear of paving than animal traction, comfortable and well-lit cars, and rapid transit. To the financier it commends itself as cheap, reliable, and offering facilities for rapid transit, which can be given in no other way. To the engineer it presents a field for the application of motive power for moving vehicles at an efficiency exceeding that which can be given by other methods, while its extreme flexibility permits its use in places which could be reached by no other means.

We have not yet come to the end of its development. Its application upon the great railways of the world is perhaps a question of the immediate future, and its adoption in a thousand forms for the purpose of manufacture and commerce has already been begun with a success which *ensures* its rapid and universal extension.

PORTSMOUTH.

REPORT BY PROF. WM. GARNETT.

To the Electric Lighting Committee of the Borough of Portsmouth.

Gentlemen,—In accordance with your instructions, I now submit to you an estimate of capital and current expenditure and receipts for the lighting of the district specified in Schedule B of your provisional order, and of the esplanade between the two piers.

The estimate is based upon the assumption that, in accordance with the recommendations contained in my report of October 14th last, alternating currents at a pressure of 2,000 volts will be employed for the transmission of energy through the main leads. Since my report was written a very complete series of tests has been carried out on the condensing turbo-generator by Prof. J. A. Ewing, F.R.S., professor of engineering in the University of Cambridge, and a copy of his report I hope to lay before you. Prof. Ewing's results show that the turbo-generator is now as efficient as the best compound engines of the marine type, and that for light loads it stands unequalled, while in the first cost of the machine, and in the items of engine-house and foundations, it enables a very considerable reduction to be made in capital expenditure. I have therefore made my estimate in the first instance on the assumption that "turbo-electric generators" with surface condensers will be employed, and have made a supplementary estimate of the additional cost which would be involved if it should be thought desirable to employ compound condensing engines of the ordinary type, making not more than 90 revolutions per minute, coupled by endless rope gearing to alternators making 300 revolutions per minute. In this estimate I have provided for engines and alternators of the highest class of manufacture obtainable.

I have assumed that a site will be procured for the central station at which sufficiently clean sea-water for surface condensers will be obtainable at all times of the tide within a distance of 250 yards. The Grammar School has been selected as the point from which the lines of high-tension mains should diverge, and it has been assumed that the distance of the central station from this point will not exceed 500 yards. If it is impossible to fulfil this condition, the extra cost of mains will be at the rate of £3,200 per mile for the distance between the central station and the Grammar School. Concentric mains will be laid from the central station to the Grammar School, capable of carrying sufficient current for twice the number of lamps for which it is intended at present to provide. These conductors together will serve all the requirements of the station until lamps have been installed equivalent to about 17,000 lamps of 16 c.p.

The system of mains which I propose to adopt is the following: Concentric high-tension mains will be laid from the Grammar School along the principal thoroughfares mentioned in Schedule B of the provisional order and Alexandra-road. Along the Commercial-road route as far as the corner of Lake-road, and to Southsea as far as the corner of Osborne-road and Palmerston-road, high-tension mains will be laid capable of carrying about twice the current for which provision is at present to be made at the generating station. This will provide for the increased demand which will occur when the system of mains is extended to North End and the Beach Mansions. The cost of extending the lighting system in these directions, including high and low tension mains and transformers, will be at the rate of about £2,600 per mile.

The high-tension mains may be concentric armoured cables of the class manufactured by Messrs. Siemens, or concentric cables protected by a lead sheathing and surrounded by 2in. of bitumen as manufactured and laid by the British Insulated Wire Company or the India Rubber, Gutta Percha, and Telegraph Works Company. Side by side with the high-tension cable, and in the same trench, will be laid cast-iron socket pipes, 4in. in diameter, securely jointed, as in the case of a high-pressure water supply, and protected within and without by a bituminous composition. Cast-iron junction-boxes, with water-tight covers, will be inserted at intervals of about 50 yards in the course of these pipes, and through these junction-boxes the conductors may be inserted or withdrawn. The low-tension conductors, having an insulation resistance of not less than 600 megohms per mile, will be drawn into these pipes, and will thus be carried by the side of the high-tension conductors throughout the town. It will not be necessary for these conductors to carry more than 140 amperes (the current for 230 lamps of 16 c.p.) over any section of the route, and where the demand for current is very small their carrying capacity will be reduced to 70 amperes, but may afterwards be increased as required by drawing additional cables into the tubes. The low-tension conductors will be fed from the high-tension mains through transformers placed at intervals, which will ultimately not exceed 300 yards, and which will be less than this in those localities where the demand for current is very great. The transformers will be inserted in boxes in the footways, but their positions will be determined by the demands of consumers; thus, if some one consumer, or two or three neighbours require, say, current for 200 lamps, a 40-h.p. transformer will be inserted immediately opposite the premises in question, and service leads will be carried directly from the transformer for the supply without utilising the low-tension mains. The transformer will be capable of supplying current for 480 lamps, so that, in addition to supplying the premises immediately opposite, the transformer will be able to supply current (168 amperes) for 280 lamps to the secondary mains, say 84 amperes, to the right and the same to the left, to be drawn off when required

at distances not exceeding 200 yards from the transformer. As the demand for current increases transformers can be put down wherever required to supply some consumers directly and to feed into the secondary mains, and small transformers may be replaced by larger instruments when necessary. Small streets will be supplied by branches from the secondary conductors only, and towards a terminus the secondary conductors may be carried 150 yards or 200 yards beyond the ends of the high-tension mains. Should any transformer break down it would be automatically cut off from the mains, but its district would be supplied with current from the adjoining transformers with only a slight falling off of the pressure. By using separate cables for the flow and return, instead of concentric cables, for the low tension conductors, it will be possible to connect new consumers or branch circuits in side streets without interfering with the continuous supply of current to the district; but if for any purpose it is necessary to cut off the supply from the section served by one transformer, this will be easily effected by disconnecting the low-tension conductors at the neighbouring junction-boxes without interfering with the supply to any other section than that so cut off. The transformers may, with advantage, be arranged as proposed by Mr. Ferranti with gear whereby they are automatically adapted for economic working with a full load or a very light load according to the demand upon them and I have based my estimate for transformers on Mr. Ferranti's figures.

The lines along which the high-tension conductors will be carried will be as follows:

(a) Concentric mains together of ·32 square inch section from the central station by the shortest available route to the Grammar School.

(b) One concentric cable of ·1 square inch section from the Grammar School along High-street to the corner of the Grand Parade. If a supply of current is required in Broad-street, a better course for this cable will be round the Inner Camber to Broad street, and thence up High street as far as it may be necessary to carry it.

(c) One concentric cable of ·2 square inch sectional area from the Grammar School to the Pier Hotel, with a branch of ·1 square inch sectional area down King's road, to the corner of Park-lane, a second branch of ·035 square inch section a distance of 100 yards along Landport-terrace, and a third branch of ·035 square inch sectional area from the Pier Hotel, along the Clarence Esplanade, to the South-parade Pier, the main conductor being carried on from the Pier Hotel, along Southsea terrace, Western parade, and Osborne road, to the corner of Palmerston road, with a sectional area of ·15 square inch, from which corner branches of ·1 square inch section will be carried along Palmerston-road to within 150 yards of St. Jude's Church and of Clarence-parade.

(d) One concentric cable of ·2 square inch sectional area from the Grammar School to the corner of Edinburgh road, with a branch of ·035 square inch sectional area extending for 80 yards along Hampshire-terrace, and a branch of ·1 square inch sectional area extending from the corner of Commercial-road and Edinburgh-road, along Queen-street and Camden-alley to the corner of Wickham street. When there is demand for current along Ordnance-row and on the Common Hard, the Queen-street conductor may be supplied directly from the central station through a high-tension conductor laid along the Gunwharf road, Ordnance row, and the Common Hard. The main line of cable will be carried along the Commercial road from Edinburgh road to Lake road with a sectional area of ·15 square inch, and from Lake-road to All Saints' Church with a sectional area of ·1 square inch.

The low-tension, or secondary conductors, laid in pipes as above described, will follow the same routes as the high-tension mains, with the following exceptions:

1. Wherever necessary the secondary conductors will be carried beyond the ends of the high tension mains to distances of 150 yards, or, in some cases, 200 yards. The secondary conductor will thus be carried to the dockyard gates, along the whole length of Hampshire and Landport terraces, to the corner of Broad street, Portsmouth, and along the Palmerston-road to the corners of Marmion-road and Clarence-parade.

2. Along the Clarence Esplanade branch low-tension conductors of only ·018 square inch sectional area will be laid in 1¼in. wrought-iron barrel. Very small transformers will be used on this section, and the current will be cut off from the whole circuit, except when the lights on the Esplanade are required. (Should a large supply of current be required for the Clarence Esplanade Pier it will probably be best to provide an entirely separate main for its supply from the central station, with telephonic communication, whereby instructions would be transmitted to the station in the event of the pier lights being required at unusual hours.)

3. No low tension conductors will be required along the route of the main cables from the central station to the Grammar School, or from the Grammar School to the corner of King's-road and to Victoria Hall, or along a portion of Edinburgh-road, unless it is desired to provide public lights along these roads.

For the purpose of public lighting in the streets, instead of arc lamps, placed at distances of 50 yards or more, I prefer to employ "high efficiency" incandescent lamps of 150 c p , fixed at distances of about 30 yards. These lamps would be supplied directly from the low-tension conductors, and two of them would require about the same power as a single arc lamp. They would need to be more frequently renewed than ordinary incandescent lamps, and this has been taken into account in the estimate of annual expenditure. A 16-c.p. lamp should, except on the Esplanade, be carried in the same lantern with the 150-c.p. lamp, and should be switched on, in the place of the larger lamp at 11 p.m., thus enabling the streets to be lighted all night, at about the same cost as would be required to maintain the larger lamps until midnight. If incandescent lamps are adopted, only very light columns will be required for their support, and they will need no attention until they require renewal, while the present lamp columns may be used in most cases. Arc lamps require expensive standards, and cost about £4 each per annum for carbons and trimming, if burning until midnight only.

As the conductors along the Clarence Esplanade will be used for public lighting only, so that all the lamps connected with them will be switched on and off together, and as no small lamps are required in this situation during the whole night, it will be convenient to switch the whole of the lights on and off simultaneously by means of a high-tension switch at the point at which the Esplanade conductors branch from the mains near the Pier Hotel. On a public promenade the lighting up simultaneously of 90 powerful lights will be effective.

For the lights along the Clarence Esplanade arc lamps are less unsuitable than in the streets, but high-power incandescent lamps would meet the requirements of the situation. If it is decided to use only a few arc lamps in special situations it seems unnecessary to provide a separate plant for arc lighting, or even to lay down a special set of mains supplied with continuous current through a rectifier, since alternating-current arc lamps may be employed, as at Newcastle, and fed from the high-tension mains through transformers, which reduce the pressure to 60 volts. One transformer may be employed for a group of seven lamps. A supplementary estimate is appended to provide for arc lights on the Esplanade and in the principal roads if desired.

Though the capital required for the installation of 8,800 private and 200 public lamps is estimated at only £40,000, it is desirable that borrowing powers should be obtained for a much larger sum, in order to enable extensions to be made to the system from time to time as the public may demand, without renewed application to the Local Government Board.

No item has been included for meters, as arrangements can, if desired, be made with the manufacturers of meters to supply them and maintain them in working order at an annual charge which would be completely covered by the rental per meter paid by consumers. If it is preferred that the meters should be purchased, the rental would suffice to pay interest on the capital outlay, and to create a sinking fund for its repayment within 10 years.

The cost of the site is another item not included in the capital estimate, as I have not yet learned whether land already the property of the Corporation will be available for the purpose, and without due information it is useless to estimate the cost of a site in a district where the value of land varies enormously with a change of only a few yards in its situation.

No allowance has been made for the renewal of lamps used for lighting the central station, inasmuch as the blackened lamps taken down from the street columns may be used in the engine-room until they are broken up.

So long as the number of private lamps wired is less than the equivalent of 8,800 60-watt lamps, the income will be less than the amount estimated below, and the expenses will also be less, but not in the same proportion. There appears, however, to be a reasonable margin to meet this difference, and if the public lighting is undertaken at once the installation may be expected to pay its working expenses and interest on capital actually invested as soon as the number of private lamps wired exceeds 5,000.

CAPITAL.

Estimate for High Speed Generating Plant and Incandescent Lamps for Public Lighting.

Buildings, including chimney shaft, boiler-room, engine-room, hot-well, offices, stores, coal stores, etc.	£5,000
Travelling crane to lift four tons	200
Cast-iron 12in. pipes for condensing water, 300 yards run laid from sea to engine room	400
Five Lancashire boilers, each 30ft. by 7ft. 6in., constructed for a working pressure of 160lb. per square inch, fixed in position with foundations, flues, fittings, firing tools, and all accessories	4,500
Three 150-unit generators, one 100-unit generator and one 75 unit generator for the production of alternating current at 2,000 volts, with condensers	7,000
Two duplex feed pumps, each capable of supplying all the boilers at full load, with steam and water pipes fixed and connected	200
Main and exhaust steam pipes with brass valves arranged so that any generator can be supplied from any boiler and exhausted into any condenser, pipes and connections between condensers and main suction and delivery pipes for circulating water, steam and exhaust pipes to auxiliary engines driving circulating and air pumps, alternative exhaust pipes carried through roof to enable any generator to be used as a non-condensing engine, and duplex arrangement of feed-water connections, all high-pressure branch steam-pipes being of copper	2,000
Main switches, fuse boards, voltmeters, ampere-meters, resistance coils, transformers for pilot lamps and lighting engine and boiler rooms and offices, with lamps and fittings for the same	800
Economiser, fixed	500
Tools	250
Spare armatures, bearings, and other parts	500
Transformers for 460 units, each transformer being wound with three separate wires in both primary and secondary	

circuits, so arranged that they can be coupled by automatic gear in "series" for light loads, and in "parallel" when the load is sufficiently increased, at £7. 5s. per unit, to include street boxes and fixing	3,335
Mains—Concentric mains of ·32 square inch sectional area from central station to Grammar School	900
High-tension mains, as above specified, exclusive of Clarence Esplanade	3,700
Low-tension mains, including trenching and making good the roads and footways, laying cast-iron pipes with junction-boxes and cables, as above specified	5,200
High and low tension mains, with junction-boxes for Clarence Esplanade	900
Lamp columns. Ninety new columns with lanterns fixed complete, and lanterns and connections to 110 gas columns	*800
Office furniture and equipment	200
Contingencies, 4 per cent.	1,600
Engineers, clerk of works, quantity surveyor, etc.	2,000
Total	£39,985

* This estimate provides only for the plainest possible type of lamp columns on the Esplanade.

RECEIPTS.

Private lighting, 352,000 units at 6d.	£8,800
Public lighting, 120,000 units at 4d., to include renewals of incandescent lamps	2,000
	£10,800

EXPENDITURE.

Coal, 472,000 units, at ·9d. per unit sold				£1,770
Wages at central station, 52½ weeks at £12. 12s.				675
Oil, waste, and other stores, at ·15d. per unit				295
Salaries				500
Law and office expenses				300
Queen's taxes on central station (£200 rental)				5
Local rates—water				50
Insurance (boiler insurance only)				50
Wages for labour in streets				150
Renewal of street lamps				350
Depreciation and repairs:				
Buildings, on £5,000 at 2½ per cent.	£125	0	0	
Running machinery, boilers, economiser, etc., on £12,200 at 7½ per cent.	914	0	0	
Steam-pipes, valves, etc., on £2,000 at 5 per cent.	100	0	0	
Instruments, etc., on £800 at 5 per cent.	40	0	0	
Tools, on £250 at 10 per cent.	25	0	0	
Traveller, on £200 at 2½ per cent.	5	0	0	
Water mains, on £400 at 2½ per cent.	10	0	0	
Office furniture, on £200 at 10 per cent.	20	0	0	
Mains, on £10,700 at 6 per cent.	642	0	0	
Transformers, £3,067 at 6 per cent., and on £268 at 2½ per cent.	190	14	0	
Lamp columns, painting, etc., on £800 at 5 per cent.	40	0	0	
say,				2,112
Interest on £40,000 at 3½ per cent				1,400
				7,639
Balance				3,161
				£10,800

In the above estimate the cost for excavation, for laying and jointing cast-iron pipes, and for making good the roads and footways, as well as for ordinary builders' work, has been taken at prices at which it is believed that the work could be easily done by local contractors, under the supervision of your engineers. If the contractors for the electrical plant and conductors are required to tender for this work, it is probable that an addition of about £1,000 will be made by them to cover risk and cost of supervision.

If 45 alternating-current arc lamps are used on the Clarence Esplanade the extra capital cost will be about £1,000, and the extra charge on revenue will be about £155 if the lamps are burning until midnight only, but this will provide no light between midnight and sunrise. If the same lamps are replaced at 11 p.m. by 32-candle lamps burning till sunrise, the extra cost on revenue account will be about £180 per annum.

If the whole of the public lighting is carried out by 100 alternating-current arc lamps burning till 11 p.m., and then replaced by 32-candle lamps burning until sunrise, the extra cost on capital account will be about £2,200, and on revenue account about £400 per annum.

If 100 continuous-current arc lamps are employed for street lighting, with rectifiers as proposed by Mr. Ferranti, the extra expenditure on capital will be £3,200 beyond the above detailed estimate and on revenue account about £480 per annum.

If an entirely separate arc lighting plant is employed, consisting of two 75-unit continuous-current generators (one being spare), one of the 150-unit plants may be replaced by a 100-unit plant, and the extra expenditure on capital will amount to about £4,000 beyond the first estimate given, but the extra expenditure on revenue account will be no greater than with the alternating currents and rectifier, as there will be no loss in transformation.

If slow-running compound condensing engines of the highest class, making from 75 to 90 revolutions per minute, and coupled by endless rope gearing to slow-running Ferranti or other alternators are employed, the extra on the foundations and buildings of the central station and crane will amount to about £2,500, and the extra on the engines and dynamos to about £5,000. The total capital expenditure will then be £47,435, and annual expenditure £8,082. If 100 continuous-current arc lamps be used for public lighting and supplied from a separate plant, driven by slow-running engines, the capital expenditure will be about £52,450, and the current expenditure about £8,600 per annum. Slow-running compound engines may be obtained at a cost much below this estimate, but the extra on the buildings and foundations cannot be avoided.

I shall be glad to learn the wishes of the committee with respect to the employment of arc lamps or incandescent lamps of high power for public lighting. With respect to this point, it may be mentioned that only incandescent lamps will be suitable for small streets, and very little extra cost would be incurred if incandescent lamps were at first employed in the main thoroughfares and supplied with current from the ordinary low-tension conductors, and were subsequently replaced by a complete system of arc lighting, and themselves relegated to the less important streets.

By the system proposed the public lights would afford work for the generating plant and utilise the mains pending the acquisition of a sufficient number of private consumers to render the private lighting plant remunerative.—I have the honour to be, gentlemen, your obedient servant, WILLIAM GARNETT.

SUMMARY OF CAPITAL EXPENDITURE.

High-speed Plant.

Buildings, crane, and water mains	£5,600
Boilers and economiser	5,000
Generators and feed pumps	7,200
Pipes, etc.	2,000
Instruments	800
Spares	500
Tools	250
Transformers	3,335
Mains	10,700
Columns and lamp fittings	800
Furniture	200
Contingencies	1,600
Engineers, etc.	2,000
	£39,985

SUMMARY OF ANNUAL EXPENDITURE.

Coal	£1,770
Wages and salaries	1,307
Stores, water, etc.	345
Office expenses, insurance, taxes, etc.	355
Renewal of lamps	350
Depreciation and repairs	2,107
Interest	1,400
	£7,634

Southsea, December 26, 1891.

ELECTRICITY UP TO DATE.

This formed the subject of an interesting lecture recently delivered at the Peel Park Museum, Manchester, by Mr. Percy A. Ramage, of Messrs. Mather and Platt's Iron Works, Salford. The lecture was delivered under the auspices of the Salford Corporation, and the chair was occupied by Councillor F. W. Roe Rycroft. The lecturer referred to the various theories which had been entertained with regard to the nature of electricity, and said that it was to Faraday that they largely owed their knowledge of the subject. The greatest advance in the use of the power had been made in producing heat for domestic purposes, and it was even used to a slight extent in heating railway carriages. The lecturer reviewed the operations connected with the telegraph, the telephone, and the phonograph, and said that such progress had been made in connection with the former instrument that six or even more messages could be sent over one line at a time. He referred to the extension of electric lighting in London and Manchester, and to the new electric railway in the metropolis, of which he gave a lucid and interesting description. In conclusion, he said that there was still a vast deal to be done in electrical engineering in saving the amount of energy drawn from coal, and it was to that object that scientists were devoting their best attention. The lecture was illustrated by numerous large diagrams, and was appreciatively listened to by a crowded audience. The proceedings were closed by a vote of thanks to the lecturer and chairman on the motion of Alderman Robinson, seconded by Councillor Phillips.

COMPANIES' MEETINGS.

TELEGRAPH CONSTRUCTION COMPANY.

The twenty-eighth ordinary general meeting of the Telegraph Construction and Maintenance Company, Limited, was held on Tuesday at the offices, 38, Old Broad-street, under the presidency of Mr. Philip Rawson, J.P., in the absence of Sir George Elliot, M.P., who was stated to be now on his way from Egypt.

The **Chairman**, in moving the adoption of the report and

accounts, said the latter showed a prosperous condition of the Company. There was a net result of £85,199, after charging interest on debentures. To this sum was to be added £61,000, brought forward from the last account. An interim dividend was paid in July last, which absorbed £22,410, leaving £124,314. Of this sum the Directors proposed to distribute a dividend of £1. 16s. per share, being at the rate of 15 per cent., and making a total dividend of 20 per cent. on the year. This would leave £57,084 to be carried forward to the next account. From the report it would be noticed that the work done during the year had been considerable. Repairs had been carried out on the Brazilian Submarine Telegraph Company's cables in the vicinity of Lisbon and Madeira, and on the Direct United States Company's cable on the coast of Nova Scotia. A duplicate cable had been laid for the Eastern Extension Telegraph Company between Madras and Penang, and a triplicate cable for the Eastern Telegraph Company between Aden and Bombay. A cable had also been laid for the Great Northern Telegraph Company between Oye, on the France coast, and Fanoe, on the coast of Denmark. During the year a length of 5,132 knots of telegraph wire had been insulated for submarine and land lines. The Gutta Percha Company was doing very good business, and, altogether, he considered the shareholders of the Company were to be congratulated on the position.

The motion was seconded by **Mr. George W. Campbell**, and carried.

NORTHAMPTON ELECTRIC LIGHT COMPANY.

A general meeting of the members of the Northampton Electric Light and Power Company, Limited, was held at the Guildhall, Northampton, last week, Mr. S. L Seckham, chairman of directors, presiding. The report stated that the mains already laid amounted to 2,800 yards, and that there were in use or being installed no less than 3,400 lights of 8 c.p. This, as Alderman Randall explained, was 1,400 lights in excess of anticipation. In consequence of the large increase in the business, it had become imperatively necessary to enlarge the machinery at an early date. The year's trading showed a loss of £461. 7s. 2d.; but that, it was explained, was owing to the expenses of a year's working being set against an income of only about three months. Councillor Cleaver and Mr. W. Tomes were re-elected directors, and Mr. Hull was re-appointed auditor. Several directors and members spoke most highly of the prospects of the Company.

ACTIEN GESELLSCHAFT: MIX AND GENEST, BERLIN.

At their last meeting the Directors of the above Company considered the balance-sheet, which showed, after writing off the usual for the depreciation on stock, a gross profit of 160,306 marks, as against 69,668 marks of the previous year. They proposed to the shareholders to write off on plant, tools, etc., 17,428 marks, and on patent account 44,634 marks, as against 4,159 marks written off patent account in the year 1890, and then to pay a dividend of 6 per cent. The extraordinary amount written off patent account, which represents nearly 4 per cent. on the paid-up capital, is far in excess of the amount written off in former years, consequently there will in future only be a nominal amount to write off annually, and so leave a larger net profit available for dividends. Both their factories are now working at high pressure, and the orders in hand are much in excess of what they were for the corresponding period of last year.

COMPANIES' REPORTS.

CITY OF BATH ELECTRIC LIGHTING AND ENGINEERING COMPANY.

Directors: Lieut-Colonel Theophilus Vaughton, J.P., Major-General J. Gordon Jervois, R.E.; Messrs Harry Newson Garrett, C.E., Alfred Pitman, Thomas Octavius Callender, Emile Garcke, Henry George Massingham, Ernest Pitman, C. J. Wharton. Secretary, Wm. Jeffery, 2, Northumberland-buildings, Bath.

Report of the Directors presented at the first annual general meeting of the Company, held at the works of the Company, Dorchester-street, Bath, on Saturday, Feb. 27.

The Directors have pleasure in submitting the first annual report and statement of accounts. The number of shares allotted is 3,246, upon which the sum of £31,981 has been paid. The result of the first year's operations of the Company is, in the opinion of the Directors, satisfactory. During the year the supply of current for incandescent lighting increased by 50 per cent., and the current is now supplied nightly to 102 arc lamps and 5,000 glow lamps. The gross profit amounts to £1,626. 8s. 5½d., and after deducting Directors' fees, salaries, and other standing charges, there remains a net balance of £585. 19s. 1½d. The Directors recommend that a dividend at the rate of 4 per cent. per annum (absorbing (£556. 16s.) be declared on the paid-up capital. The Directors have not written off any amount for depreciation, but all repairs and renewals have been charged to profit and loss account, and care has been taken to keep up all the plant to its original working efficiency. The engineer-in-chief, Mr. Ollson, reports: "In accordance with your request, I have pleasure in informing you that the plant is in good working order. The engines and dynamos have been kept in thorough repair, and the mains, both for arc and incandescent lighting, are in perfect order." The Directors propose, in order to meet future depreciation of machinery, and to provide for exceptional outlay in any one year, to constitute a renewals fund, to which the balance of revenue, after providing for the dividend above mentioned, will be carried. The electric light is finding increasing favour in the city, as is evidenced by the many fresh installations. Among other buildings, the Bath and County Club has been fitted throughout. Deputations from various towns have visited Bath during the past year, for the purpose of inspecting the Company's works and lighting arrangements. The general testimony is that the central station is one of the most successful yet carried out, and the only improvement suggested by the deputations is that in some parts of the city additional arc lamps should be erected. The Directors anticipate that the coming year will show even better results, and they are giving special attention to the question of reducing the initial charge for installing the electric light. They are also considering the question of giving a day and night supply of electricity.

PROFIT AND LOSS ACCOUNT, 1891.

Dr.	£	s.	d.	£	s.	d.
Working expenses				4,318	15	4½
Standing charges—						
1. Directors' fees	46	4	0			
2. Salary of secretary, engineer, electricians, and other officers	656	11	5			
3. Rent, rates, and taxes	226	10	10			
				929	6	3
Stock, decreased value				111	3	1
				5,359	4	8½
Balance—profit				585	19	1½
				£5,945	3	10

Cr.	£	s.	d.
Proceeds of sale of current and installations	5,863	18	6½
Discounts and other receipts	81	5	3½
	£5,945	3	10

BALANCE-SHEET MADE UP TO 31ST DECEMBER, 1891.

Dr.	£	s.	d.	£	s.	d.
Capital—						
3,246 ordinary shares of £10 each	32,460	0	0			
Less calls in arrear	479	0	0			
				31,981	0	0
50 deferred founders' shares of £100 each				5,000	0	0
Creditors—						
Sundries	1,215	13	8½			
Balance of purchase-money of undertaking (unpaid)	1,834	7	11			
				3,050	1	7½
Profit and loss—						
Balance, being net profit				585	19	1½
				£40,617	0	9

Cr.	£	s.	d.	£	s.	d.
Property—Plant, mains, construction, and sundries:						
Price paid to vendors	29,864	4	3			
Additions	2,290	3	7			
				32,154	7	10
Preliminary expenses				1,287	17	2
Goodwill (founders' shares)				5,000	0	0
Debtors—						
For current supplied, and installations	1,354	4	4			
Stock, goods on hand	584	6	4			
Cash at bankers	230	5	3			
Cash in office	5	19	10			
				2,174	15	9
				£40,617	0	9

APPROPRIATION ACCOUNT.

Dr.	£	s.	d.
Dividend at the rate of 4 per cent. on paid-up capital since formation of Company	556	16	0
Balance carried forward to next account	29	3	1½
	£585	19	1½

Cr.	£	s.	d.
Balance brought down	585	19	1½
	£585	19	1½

KESWICK ELECTRIC LIGHT COMPANY.

The annual report of the Directors of the Keswick Electric Light Company has been issued. During the past year they have experienced great difficulties in having to run the station with plant only partially supplied with water power, in consequence of which considerable expenditure has been incurred in providing steam power to supply the deficiency. The business of the Company continues to increase, and in order to meet the requirements it has been found necessary to make considerable extensions in the main-wiring, the advantages of which to the Company are not fully felt. Notwithstanding these difficulties and the extraordinary working cost, the Directors have satisfaction in presenting a statement of accounts which shows a balance upon the year's working

of £87. 8s. 5d., which, being added to the balance left over from the previous year, leaves a sum of £122. 4s. They propose the payment of a dividend of £3 per cent., which will leave £44. 10s. 7d. to be carried forward to the next account. The receipts from consumers amount to £541. 11s. 2d.

NEW COMPANIES REGISTERED.

Pioneer Telephone Company.—The Pioneer Telephone Company, Limited, has been formed with a capital of £100,000 in shares of £10 each, for the purpose of acquiring certain rights and interest secured to the Electric and General Investment Company, Limited, under which the undertaking of the Mutual Telephone Company, Limited, in Manchester, may be acquired as a going concern. It has also been formed for the purpose of providing the necessary capital for the New Telephone Company, Limited, the objects of which are the acquisition, establishment, and working of telephone exchanges throughout the United Kingdom under license. Seven thousand five hundred shares were offered for subscription. The officers are as follows: Board of Directors, the Duke of Marlborough, 3, Carlton House-terrace, S.W., Colonel the Honourable Oliver Montagu, 3, Mount-street, W., Charles Praed, Esq., Lloyds Bank, Limited, F. E. Savory, Esq., West Suffolk County Club, Bury St. Edmunds; bankers, Lloyds Bank, Limited; brokers, Messrs. Foster and Braithwaite, 27, Austin-friars, E.C.; solicitors, Messrs. Dawes and Sons, 9, Angel-court, E.C.; auditors, Messrs. W. H. Pannell and Co., 13 and 14, Basinghall-street, E.C.; secretary, J. Cecil Bull, Esq.; offices, Nos. 1 and 2, Great Winchester-street, London, E.C.

BUSINESS NOTES.

City and South London Railway.—The receipts for the week ending 28th February were £834, against £754 for the corresponding period of last year.

Eastern Telegraph Company.—The traffic receipts of this Company for February were £58,284, as against £59,155 for the same period of 1891, a decrease of £871.

Submarine Cables Trust.—The coupon due in October last of the Submarine Cables Trust will be paid in full on and after the 15th inst. by Messrs. Glyn, Mills, and Co.

Eastern Extension Telegraph Company.—The receipts of this Company for February amounted to £39,002, as against £43,883 in the corresponding period, showing a decrease of £4,831.

PROVISIONAL PATENTS, 1892.

FEBRUARY 22.

3423. **Improvements in telephones.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London.

3427. **A new carbon electrode for electric arc lighting, to be called the electric torch.** Carl Anton Johannes Hugo Schroeder and Heinrich Eugen Richard Schroeder, Whetstone House, Heslop-road, Balham, London.

3443. **Improvements in electric arc lamps.** George Hughes, 38, Chancery-lane, London. (Charles Henri Octave Japy and Oscar Helmer, France.) (Complete specification.)

FEBRUARY 23.

3472. **Improvements relating to incandescent lampholders.** Reuben James Bott, 9, Park-place-villas, St. Mary's, Paddington London.

3488. **An improved method of coiling up conductors of portable electric lamps.** Alexander Charles Hamilton, 41, Lennox-gardens, Chelsea, London.

3512. **Improvements in the process of electrolysing alkaline salts.** George Dolor Davis, 25, Bedford-place, Russell-square, London.

3513. **Improvements in diaphragms for electrical cells.** George Dolor Davis, 25, Bedford-place, Russell-square, London.

3514. **Improvements in the process of electrolysing alkaline salts.** George Dolor Davis, 25, Bedford-place, Russell-square, London.

3521. **Petroleum lamp with electrical igniting device.** Oliver Imray, 28, Southampton-buildings, London. (Carl Wasmuth, Germany.)

3523. **Improved galvanic element.** Oliver Imray, 28, Southampton-buildings, London. (Carl Wasmuth, Germany.)

3538. **Improvements in distributing and controlling electric currents in mines or other dangerous places.** Robert John Charleton and Henry Walker, 46, Lincoln's-inn-fields, London.

3542. **Improvements in telephone apparatus.** Henry Harris Lake, 45, Southampton-buildings, London. (William Gray, United States.) (Complete specification.)

3560. **Improvements in trolley-wire hangers and other appliances for use in overhead electric railway systems.** Smith W. Kimble, 55, Chancery-lane, London.

3561. **Improvements in trolley wheels for electrically-propelled vehicles.** Smith W. Kimble, 55, Chancery-lane, London.

3562. **Improvements in the construction and mounting of electrical connecting devices upon their non-conducting supports.** Smith W. Kimble, 55, Chancery-lane, London.

3569. **Improvements in the glass chimneys, globes, and shades of electric and other lamps.** Albert Cay, trading as James Stevens and Son, and also as Stone, Fawdry, and Stone, 7, Staple-inn, London.

3572. **Improvements in apparatus for electrically operating or controlling type-writing machines, type-setting machines, or apparatus for recording, indicating, or signalling.** Archibald FitzGerald Law, 45, Southampton-buildings, London. (Edward FitzGerald Law, Russia).

FEBRUARY 24.

3595. **Improvements in shades and reflectors for incandescent electric lamps.** Frederick Moore, 57, Colmore-row, Birmingham.

FEBRUARY 25.

3654. **Improvements in electric burglar alarms.** Ernst Richter, 70, Market-street, Manchester. (Complete specification.)

3662. **An improved method of electric traction: underground system.** William Robert Clapcott Wakley, 23, Princes-square, Bayswater, London.

3707. **Improvements in electric arc lamps.** John Clayton Mewburn, 55, Chancery-lane, London. (Paul Sée, France).

3719. **Improvements in apparatus or switches for controlling electric currents.** Arthur Basil Burnand, 47, Lincoln's-inn-fields, London.

3724. **An improved electric arc lamp.** Hermann W. Sander and Martin D. Memmell, 55, Chancery-lane, London.

FEBRUARY 26.

3758. **Improved holder for incandescent electric lamps.** William Frederic Parkinson, 7, Kemys-street, Griffithtown, near Newport, Monmouth.

3801. **Improvements in electric bells.** Leslie Watt Winnall and William Howard Winnall, 4, South-street, Finsbury, London.

FEBRUARY 27.

3873. **Improved insulating media for electrical conductors.** Henry Cornelius Donovan, 53, Chancery-lane, London.

3875. **Improvements in and relating to electric motors.** Carl Coerper, 45, Southampton-buildings, London. (Complete specification.)

3881. **Improvements in electrical accumulators.** Karl Kahabka, 4, South-street, Finsbury, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1891.

3748. **Electrical insulators.** McLean.
4860. **Heating and welding by electric arc.** Howard.
5712. **Insulating electrical conductors.** Pitt. (Davidson.)
5713. **Insulating electrical conductors.** Pitt. (Davidson.)
5714. **Insulating electrical conductors.** Pitt. (Davidson.)
5835. **Electrical measuring instruments.** Jones.
5918. **Electric batteries.** Harris and Power.
6372. **Electric time-calls.** Varley.
12982. **Electric time-check.** Wetherfield.
13942. **Electric circuits.** Parker and others.
18093. **Electric fire alarms.** Elkington. (Compania Electricista contra Incendios).
18348. **Distribution of electricity.** Parker and others.
21728. **Electric arc lamps.** Waterhouse.
22482. **Voltaic cells.** Lake. (Weston.)
22820. **Telephones.** Furtado and others.

1892.

106. **Electric switches.** Sturge.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3⅞
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	21¾
House-to-House	5	5
Metropolitan Electric Supply	—	8⅝
London Electric Supply	5	1¼
Swan United	3½	4½
St. James'	—	8¾
National Telephone	5	4⅞
Electric Construction	10	6¼
Westminster Electric	—	6¼
Liverpool Electric Supply	5	5
	3	2⅝

NOTES.

Salisbury.—Tradesmen at Salisbury are complaining of the insufficient lighting of the streets.

Telephone Bills.—No less than 112 separate opponents desire to appear in opposition to the Telephone Bills.

Physical Society.—Prof. Perry will read a paper on "Choking Coils," at the Science Schools, South Kensington, at 5 p.m. to-day (Friday).

Birmingham Cars.—The new cars designed by Messrs. J. E. H. Gordon and Co. for the Birmingham line are ready, and will be tested shortly.

Oil Engines.—Prof. Wm. Robinson continues his Cantor lectures on "Oil Engines" before the Society of Arts on the next two Monday evenings.

Electric Spark Photography.—Mr. C. V. Boys will lecture on the above subject at the Lecture Theatre, South Kensington Museum, on Saturday, at 3 p.m.

Edinburgh Tramways. — The Edinburgh Town Council have unanimously agreed to purchase the tramways on the expiry of the company's lease in June next.

Assessment of Telephone Wires.—At South Stoneham the assessment for the telephone company is at the rate of £1 per mile net rating throughout the union.

Explosion.—The following is from the *Bulletin International*: "The boiler at the Garnot station at Provins having exploded, the distribution of light is suspended." No doubt it would be.

Deputations.—Under the guidance of Mr. W. H. Preece and Mr. MacGeagh, a large party, many of them members of the Commissioners of Sewers, visited the Crystal Palace Exhibition last week.

Electric Cooking.—A room in the South Nave of the Crystal Palace Exhibition has been fitted by Messrs. Crompton with electric heaters; and its advantages will be explained daily by Mr. H. J. Dowsing.

Electric Transmission of Power.—M. F. Kéramon begins a historical *résumé* of the developments of transmission of power by electricity in *Cosmos* for March 5. The experiments of M. Marcel Deprez occupy the first number.

Blackpool.—The Electric Lighting Committee have decided to recommend the extension of the Promenade lighting. It is also intended to light some of the streets, and to supply the shops and places of business that require the light.

Engineers' Exchange.—Mr. Reginald Bolton, of the Institution of Civil Engineers, advocates the establishment of a Central Engineering Exchange on the model of the Coal and Corn Exchanges, where on given dates members might certainly be found.

Crystal Palace Exhibition.—It may be interesting to our readers to learn that the admissions to the Palace during the present electrical exhibition have been to date about 41,000 more than during the corresponding period of the exhibition held 10 years ago.

Birkdale.—The Local Board of Birkdale (near Southport) have had complaints of the insufficiency of the gas supplied by the Southport Corporation. The suggestion by Mr. Barrett, that the Board had better adopt the electric light, met with the hearty support of the chairman.

College Dynamo.—The Edison dynamo which is well known to so many electrical students at Finsbury, has been replaced by a larger Kapp machine. We believe that the Edison machine, which is in good condition (110 volts and 150 amperes), is for disposal for a nominal sum.

Bristol.—The plans embodying a first plant of 1,500 h.p. are now practically complete, and it is to be expected that tenders will be invited before long. The arrangements for coal feeding and so forth will make the station almost automatic, only two attendants being required.

Distribution of Electric Lighting.—At the meeting of the North-East Coast Institution of Engineers and Shipbuilders, to be held at West Hartlepool on Thursday, March 17, a paper on "The Distribution of Electricity for Lighting Purposes" will be read by Mr. J. Brentnall Duckitt.

Manchester Deputation — The Manchester Gas Committee are now in London. On Wednesday they visited the South London Railway generating station, subsequently visiting the Crystal Palace, their visit being private. The object is mainly to see electrical plant in operation.

House of Commons Lighting.—Whilst the electric light has been applied in the House of Commons at an annual cost estimated for the coming year at £1,800, the gas bill increases rather than diminishes. Last year it was £3,000; for the coming year it is believed it will not be less than £3,200.

"Electrical World."—Dr. Louis Bell, who has been editor of our esteemed contemporary the *Electrical World* for the past two years, has retired from that position to undertake more direct engineering work. Mr. Carl Hering, who has long been connected with the paper, takes charge of the technical department.

Comparison of Cost.—The detailed accounts published of the lighting of the municipal buildings of Vienna, where both gas and electricity are used, shows that, per hour of lighting, the price of electricity is 46 per cent. higher than gas. It is expected that considerable greater economy will be experienced during the coming year.

Bournemouth.—At the last meeting of the Bournemouth Town Council, the General Purposes Committee reported that the Board of Trade had consented to grant a license for the lighting of the pier by electricity. The committee recommended that the necessary application be made for the license. The report was adopted.

Royal Meteorological Exhibition.—An exhibition will be held by the Royal Meteorological Society from Tuesday, 15th, to Friday, 18th inst., at the Institution of Civil Engineers, Great George-street, of instruments, charts, maps, and photographs relating to climatology, and of such new instruments as have been invented since last exhibition.

Carmarthen.—A special meeting of the Carmarthen Town Council has been considering the question of public lighting. Gas is 4s. 6d. per 1,000, and the bill for the year comes to £450 for 191 lamps. The Council is intending to offer a lower price to the gas company. A little information on electric lighting might not come amiss to the Council.

Telegraphic Communication to Shetland.—At the last meeting of the Shetland Mails Committee, held at Lerwick, it was decided to petition the Post Office authorities to lay a cable connecting the outlying island of Fair Isle with the mainland; also to make arrangements for extending the telegraph to the island of Fetlar at as early a date as possible.

Aberdeen Public Library.—At a meeting of the subcommittee appointed in connection with the lighting of the Aberdeen Public Library it was decided, in view of the

fact that the building is to be lighted at an early date with electricity, that the gas fittings to be introduced should be of an inexpensive character, and such as would be suitable for adaptation to the requirements of the electric light.

Llanelly.—At a meeting of the Llanelly Local Board on Monday, a letter was read from the Llanelly Electric Light and Power Company with reference to the proposed electric lighting of the town, in which they asked the Board to name their terms for the handing over of the provisional order. A tender was also received from Messrs. J. D. F. Andrews and Co., but the matter was referred to a committee of the whole Board.

Coventry.—With reference to the deputation of the Coventry Town Council to the Crystal Palace, Mr. James, in the discussion as to its advisability, said he doubted whether it was needed as they had appointed a consulting electrical engineer, they had his advice, and this advice ought to be taken. He thought it unadvisable to reopen the question. The deputation, however, as already stated, was appointed, and will visit the Exhibition.

Whitehaven.—At the meeting of the Whitehaven Town and Harbour Trust, with reference to the electric lighting, the chairman said the surveyor had received a further tender from Messrs. Andrews. As that matter was referred by the Board to the Joint Harbour and Street Committee, he thought it would be convenient if a joint committee meeting could be summoned. This was agreed to. The meeting will take place on Tuesday.

Electric Travelling Crane.—The *Elektrotechnische Zeitschrift* for March 4 contains an article, with illustrations, of the new electric travelling crane built by the Allgemeine Company, of Berlin. It is mounted on a peculiar beam of L-shape, running on wheels, one rail being on the ground and the other near the roof of the warehouse. The crane is mounted on this beam in a covered house, and the motor winds up, slows, and also drives the travelling gear.

Tesla's Experiments.—The French papers this week are full of Mr. Tesla and his brilliant experiments. No man in our age has achieved such a universal scientific reputation in a single stride as this gifted young electrical engineer. The *Nineteenth Century* contains an article by Mr. J. E. H. Gordon, introducing the subject to the literary world in admirable and brilliant style reflecting both the scientific depth and the coruscations of the original experiments.

Taunton.—The question of the purchase of the electric works at Taunton caused a little scene at the last Town Council meeting. When the matter came up Alderman Standfast moved that the books of the company should be open to inspection, but several members left the Council-chamber, and one member declined to vote as he was a director of the company. So nothing could be done, Alderman Standfast exclaiming, "So that's their little game!"

Coast Communication.—Sir Michael Hicks-Beach, at the annual meeting of the Association of Chambers of Commerce, said that the Government would shortly state their views on the subject of telegraphic communication to light-houses and lightships, when Sir Edward Birkbeck's motion came before Parliament. Sir Edward Birkbeck stated that every member who had communicated with him was in favour of a Royal Commission. A motion to press the question was carried unanimously.

Colliery Lighting.—The Duke of Sutherland has accepted the tender of Mr. Joseph Blackburn, Gresham Works, Nottingham, for the supply and erection of engines, dynamos, and plant for lighting by electricity the Florence Collieries, and also a special arrangement by which the sinking of a new shaft can be carried on night and day. This shaft will be over half a mile in depth when completed. The whole work has been arranged and will be carried out from the designs of Mr. W. J. Furse.

Poisoning by Oxide of Copper.—An electrical workman recently was poisoned at Berlin in a very peculiar manner, which it will be well for electrical engineers to note. He had been used in testing his cells to find if current was flowing to put the two ends of his wires in his mouth, and the oxide of copper produced eventually caused his death. The galvanometer is now substituted in that workshop for this rough-and-ready test, which evidently is more dangerous than most persons would believe.

Blackpool.—The minutes of the Electric Lighting Committee, presented at the meeting of the Blackpool Town Council last week, stated that a draft report had been prepared, and that Mr. R. Hammond and Mr. Goode (Hammond and Co.) had had an interview with the committee on the subject of electric lighting. The Mayor, in moving the adoption of the minutes, said that inasmuch as their powers would very shortly expire, he hoped that the committee would push on their enquiries and lose no time in presenting a full and exhaustive report to the Council.

Teignmouth. — The Teignmouth Local Board on Monday considered the project which Mr. Reed, of Chagford, brought forward for lighting the town by electric light, at a cost of £12,500, on the low-tension system with accumulators. The chairman said he had received letters from Hammond and Co. and the Manchester Edison-Swan Company asking to be allowed to tender. It was stated that the extension of the gas work would cost £6,000. There is no water power near. Mr. Wheatley moved that the lighting of the town with electricity be deferred, and the motion was carried.

Southport.—At the monthly meeting of the Southport Town Council on Tuesday, the arrangements being made for the adoption of the electric light in the principal thoroughfares were brought up with reference to the Gas Committee's report. Alderman Hacking said they must avoid letting the supply remain in the hands of a company, who would make a profit of 10 per cent., for the Corporation could put the electric light into operation themselves by borrowing money at 3 per cent. He strongly advised the Corporation to undertake the manufacture of their own electric light. The minutes of the committee were confirmed.

Newington.—At the last meeting of the Newington Vestry the Works and Sanitary Committee recommended, and it was resolved: "That the Vestry offer no objection to the order lodged by the Camberwell and Islington Electric Light and Power Supply Company, Limited, to light this parish by electricity, subject (1) to the company consulting the vestry clerk and chairman of the Works Committee before purchasing or leasing a site in the parish for the purpose of a generating station, and (2) upon the compulsory area being extended from the Vestry Hall, Walworth-road, to the boundary of the parish in Camberwell-road.

Time Cut-outs for Motors.—Where arc lights or motors are ordered for supply during a certain period every day it is evidently to the advantage of the supply company to cut off the current at the exact time for which the contract is made. The Electric Secret Service Company have introduced a clock switch, which may find a useful field for this purpose. The clock is furnished with discs, notched in a suitable way on the periphery, which cuts the current in or out at the time stipulated. The discs can be made to act at various times and for various periods

every day. The apparatus is illustrated in the *Electrical World* for February 27.

Swindon is greatly occupied with the question of public lighting, and a large ratepayers' meeting has been held. Mr. A. D. Williams said there was no doubt whatever that the lighting of the future would be by electricity. He did not think it would be advisable for the Local Board to lay down a new gas plant or purchase the old one, as it was only a question of time before lighting by electricity became very general. The chairman remarked that the electric light would not supersede gas altogether, but it would tend to reduce the price of gas. The idea that electric light should be used, it seems, is rapidly growing.

Aluminium Manufacture in India.—Prof. Alfred Chatterton, B.Sc., of the Madras Engineering College, has a very suggestive paper in the *Indian Engineer* for February 6th upon the possibility of utilising the immense water power of India for the electric production of aluminium. Prof. Chatterton enters very fully into the practical details and financial aspect of the proposed scheme for the use of 125,000 h.p. He suggests the investment of £1,000,000, and shows figures, which, though rough, are, he maintains, under rather than overstated, resulting in a profit capable of returning 75 per cent., with aluminium at £200 a ton. Meanwhile it is suggested that a syndicate secure from Government the right to use the water power of the Periyar project.

Hobart Tramways.—The Hobart Tramway Company has been brought out this week with the capital of £105,000 (College-hill-chambers, Cannon-street), to establish three miles of electric tramways in Hobart, Tasmania, on the overhead conductor system. A contract has been made with Messrs. Siemens and Co. to equip the line with 20 cars and the electrical fittings and accessories for working the tramways, for the sum of £33,000, the work to be completed so that the line may be ready for opening for public traffic by the 1st of December, 1892. This firm has also agreed to work the line until the 31st December, 1893, at 4d. per car mile, receiving not less than £1,000 per month, including in same wages of conductors, drivers, and of all the necessary maintenance staff.

Glasgow Tramways.—The minutes of the Tramway Committee presented to the Glasgow Town Council last week contained the report of the sub-committee on mechanical haulage, and notes of their visit to Chester, Birmingham, London, and Leeds. Bailie Paton, in moving the adoption of the report, said the Electric Traction Company still held open their offer. Possibly the best information the deputation received was at Leeds, from the overhead conductor line, and they were extremely pleased and delighted with what they had seen. The three miles of track had cost £20,000, and had been laid down in less than six months. The present lease in Glasgow had two years yet to run, so that there was plenty of time to watch the development in Leeds before they made up their mind to adopt electric traction. The minutes were approved.

Bradford.—The minutes of the Bradford Gas and Electricity Supply Committee included a resolution advancing the salary of Mr. S. W. Baynes, manager of the electricity works, from £250 to £300 per annum. Objection was taken to this, unless it were possible at the same time to dispense with the services of the consulting engineer, Mr. Shoolbred. Alderman F. Priestman defended the action of the committee, contending that Mr. Baynes was a most valuable servant, and was entitled to be better remunerated now that the electric works were becoming profitable. As to Mr. Shoolbred, he protested against the attempts to injure that gentleman's professional position, which was similar to that of an architect, and for all the work he did he only received the small commission of 3 per cent. The proceedings were confirmed by a large majority.

Electric and Cable Railway Bills.—On the motion of Lord Balfour, last Friday the House of Lords concurred in the following resolution communicated by the Commons: "That a joint committee of Lords and Commons be appointed to consider the best method of dealing with the electric and cable railway schemes proposed to be sanctioned within the limits of the metropolis by Bills introduced, or to be introduced, in the present session, and to report their opinion as to whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and probable future traffic; as to whether any, and which, of the schemes propose satisfactory lines of route; as to the terms and conditions under which the subsoil should be appropriated; whether any and, if any, what schemes should not be proceeded with during the present session."

Sims-Edison Lifeboat.—Mr. Edward Palliser, in a letter to the *Times* of Monday, states that Mr. Sims is preparing drawings for adapting the Sims-Edison electrical motor and propeller to lifeboats. The system will be the same as used in the Sims-Edison torpedo recently tested at Portsmouth. The propeller will be placed in the bow, to bite the water as soon as possible with 45 h.p. The cable coiled in the boat will be from three to four miles long. The boat would be provided with a search-light. The electric current would be generated from the shore station, which may be two miles from the starting point of the lifeboat. He adds that Mr. Edison is taking the greatest interest in this new departure. The proposal, we may remind our readers, has already been mentioned, and a trial will be witnessed with great interest. It remains to be seen how electric cables would behave when attached to a lifeboat in a storm.

City Lighting.—The solicitor to the Commissioners of Sewers at the meeting on Tuesday submitted his report, showing that the dates of the contracts for the electric lighting of the east and central districts had expired. The clerk read a letter from the City of London Company, saying the total length in these districts was 31,105 yards, of which 24,388 yards was laid, and at this rate the work would be finished in three weeks. The contract for the western district expires November 5, by which time it would be complete. The solicitor explained that £1,000 had been deposited as caution-money. Mr. Johnson strongly opposed the resolution of Mr. C. T. Harris to consider the whole question in committee, saying it would be most dangerous to interfere; it was impossible to do the work quicker, or the whole traffic in the City would be stopped. The Court refused to move the resolution.

High-Tension Experiments.—The days when 2,000 volts were considered dangerously high are fast disappearing into the limbo where the idea of the danger of 40lb. of steam has gone. Nothing under 50,000 volts will content experimenters of the present day. Messrs. Siemens have this potential going at the Crystal Palace Exhibition, and we are now in receipt of an invitation from the Old Students' Association to their next meeting at the Central Institution, this evening (Friday) at 8 p.m., when a paper will be read on "The Behaviour of Insulating Materials under the Action of High Potential Differences," by Messrs. H. B. and W. Fox Bourne, members, illustrated by experiments with a transformer giving about 50,000 volts. Members may invite friends. Considering the importance that the subject is assuming, the Old Students should

obtain a large attendance. It is rather a pity the notice was not issued a little sooner.

Rochdale.—The councillors of Rochdale have been roused to a sense of the necessity for action with reference to the electric light by reading of the action taken by the Salford Corporation. But it turns out that Rochdale has no powers as yet for the introduction of electric mains, while Salford has, and fears to lose them. Several companies, it appears, have given notice that they wish to introduce electric light into Rochdale, but have always been opposed. Alderman Petrie said the committee were not standing in the way of the light, and as soon as they felt there was sufficient desire in the town they would introduce it. Alderman Heape made a suggestion as to the commencement of an installation by using the water power on the sewage farm, where there was a disused cotton mill which would give 40 h.p. This might be used at the technical school, library, and Town Hall. This is to be brought before the Gas Committee. The Mayor, who has the electric light on his premises, said the trouble was that his gas bill was almost as large as before, so much more light being used.

Burnley.—At the monthly meeting of the Burnley Town Council last week, Alderman Lancaster, in seconding the Gas Committee's report, said they were making progress with the electric lighting, though not so rapidly as they desired. At the present moment they were very much pestered with people who wished to show them various systems for working the town with electricity. The proposal of their engineer (Mr. Parker) was to put down Lancashire steam boilers driving horizontal engines at high speed with rope driving on to the dynamo, thus differing from the schemes of many electrical engineers who advocated driving the dynamo direct on the same shaft. Mr. Parker proposed to use the high-tension three-wire system with transformers. The committee proposed to erect a station on the plot of land to the left of the proposed new aqueduct, which would be one of the most central sites that could be obtained. The Council passed the recommendations of the committee, amongst which was one directing application to be made to the Local Government Board for sanction to borrow £25,000 for electric lighting purposes.

Mansion House Lighting.—A private view of electric lighting at the Mansion House was held on Monday evening to meet the Lord Mayor and Lady Mayoress. The installation, which has been carried out by the Planet Electrical Engineering Company, consists of 825 lamps of 5, 8, 16, and 50 candle-power. These lamps have been fitted over the whole of the Mansion House, including the following principal rooms: Egyptian Hall, Venetian Room, Long Parlour, Saloon, State Drawing-room, Lady Mayoress's Boudoir, Justice-room, and Morning-room. The whole of the work has been carried out to the specification of Mr. W. H. Preece, F.R.S., and the wire has been run in such a manner that not more than 10 lamps are placed upon one circuit, and economical burning has been fully worked out by arranging that the lamps on all the cluster fittings are split up into two or more circuits, so that a few lights for general use may be turned on instead of the whole of the lamps. The general effect is extremely handsome. The Lord Mayor stated his satisfaction with the installation, and during the evening the Lady Mayoress was presented with an ebony and silver portable lamp as a memento.

Bradford Electric Cars.—A short length of tramway line in Bradford has been taken in hand by Mr. Holroyd Smith, who has equipped it with overhead conductors for electric traction, for the purpose of experiment, with the co-operation of the Bradford Corporation, who will supply the current from their central station. The line has now been completed, running from Foster-square, up Cheapside, to Manor-road and Manningham-lane. Experiments will be carried out this week, and the car, which has been built for the purpose, will be run on the existing lines leased by the Bradford Tramways Company, the directors of which have given every facility for the experiment. The car will run for a few weeks, and the public will be carried at the charge of 1d. Official inspection by Major-General Hutchinson takes place this week. The car will seat 18 persons inside and 18 outside, the roof being fitted with garden seats. Great interest is aroused in the town, especially with reference to the steep gradient at Cheapside, where there is also a sharp turn. Should the experiment prove satisfactory the installation may be made permanent, though probably, it is stated, a conduit system may be used.

Catalogue of Ship Machinery.—The very enterprising Newcastle company, Ernest Scott and Mountain, Limited, have issued a valuable catalogue of engines and auxiliary machinery for war and passenger ships, which will be of interest to all who have to do with this class of machinery contracts. Triple expansion inverted cylinder engines, fitted with automatic expansion gear, for 150lb. steam pressure, make a very efficient prime motor for electric light stations. Solidly constructed combined engines and dynamos of Admiralty pattern have been specially designed to conform with Admiralty requirements for use where space is limited. Another form of combined plant shown in the catalogue is a compound vertical engine and Tyne dynamo, of which many sets are in use. Another form consists of horizontal engine and Tyne dynamo on the same bed-plate for situations where head room is limited. The catalogue further contains illustrations and descriptions of feed, fire, and bilge pumps, air and circulating pumps, workshop engines and condensers, also various classes of forced draught fans suitable for warships, besides hydraulic pumps, and illustrations of the large class of gunmetal castings that their foundry is capable of producing.

Oxygen and Ether.—Prof. Dewar's beautiful experiments demonstrative that liquid oxygen is powerfully magnetic ought, we think, to lead to some important modifications of the theory of magnetic circuits as taught in the text-books. What a boon to students it would be if we could only get rid of the necessity for the conception of ether altogether, especially in the early stages, where a clear idea of the interactions of molecular force is requisite! Ordinarily, the student is led to believe that magnetism is some force resident in the molecular structure of the iron or steel, but that outside the iron or steel the magnetic effect is transmitted by the ether. Why not attribute this exterior action to the effect upon the molecules of the oxygen of the air itself? We shall then have a clear conception of the whole magnetic circuit acting partly through the iron and partly through the oxygen. Even with an exhausted bulb we are perfectly aware that millions of molecules are necessarily left, and with freer paths for activity than before. Would it not be preferable to conceive the magnetic effect as being transmitted by actual magnetic effect upon the oxygen molecules, rather than leave this function to an unknowable ether?

St. Pancras.—Mr. Andrew Sweet, chairman of the St. Pancras Electricity Committee, has addressed the following letter to the editor of the *Times*: "Sir,—Paragraphs have been sent to several newspapers and an impression already widely prevails that the Vestry of St. Pancras, having withdrawn their Parliamentary Bill, are tired of electric lighting, and have no intention of extending

it in the parish. This is entirely a mistake. The first object of promoting the Bill was to raise money from the public when a difficulty arose between the Vestry and the London County Council as to the period over which the repayment should extend. Since then the difficulty has been surmounted and the necessary money has been borrowed. The present necessity for the Bill, therefore, has gone. I may add that electric lighting in St. Pancras is an assured success, and the Electricity Committee are now taking the necessary steps to extend the public lighting, which was commenced in Tottenham Court-road and Euston-road, through Hampstead-road and Camden Town. Furthermore, every day during the last fortnight we have at least one new applicant for current, and this morning comes an application from one consumer for about 600 lights."

Underground Sub-Stations.—A letter was read before the Beckenham Local Board, on Monday, from the Crystal Palace and District Electric Light Supply Company, Limited, asking the Board's permission to construct an underground apparatus in Sydenham-terrace. The company's secretary and manager (Mr. George Offor) attended the Board meeting. The Works Committee recommended the Board to sanction the application subject to an agreement at a rent of £10 per annum, and that the Board's surveyor reported that it was possible to accede to the request. Mr. C. E. Baker said what the company proposed to do was to bring in electricity of 2,000 volts strength, which would be reduced before being used to 200 volts. The chamber in which it was proposed to store the electricity would be divided into two compartments, one of which would contain motor-dynamos and the other accumulators. The chamber would be entered by a 2ft. door, and would be 40ft. long by 20ft. wide. The chamber would only be visited once a day, and dynamos would be continually running. The Board, it was maintained, had no power to authorise the construction, as they had no authority further than the surface of the soil, and the chamber would be between the footpath and the highway. After some similar remarks from Mr. Grenside the application was referred to a committee.

Oxford.—At the monthly meeting of the Oxford City Council last week, the General Purposes Committee recommended the Council to appoint a standing committee, to be called the Electrical Committee, to deal with all matters relating to the introduction of electric lighting into the city, with power to obtain the assistance and advice of a practical electrical engineer. The following were appointed: The Mayor, the Sheriff, Aldermen the Provost of Queen's, Wilson, Deazeley, and Green; and Councillors Underhill, Morrell, Shadwell, Ogle, Kingerlee, Salter, Daniel, Rose, and Colonel Swinhoe. The Parliamentary Committee reported they had considered an application from Messrs. Walter Webb and Co., solicitors to the Electric Installation and Maintenance Company, Limited, as to their application to the Board of Trade to sanction a transfer to the Oxford Electric Lighting Company, Limited, of the provisional order, and recommended the Council to assent to the transfer. Alderman Deazeley said the committee thought that with the deposit of £1,500 the ratepayers were held safe in respect to damage to the streets, and they thought also, as the new company had precisely the same liabilities and responsibilities, there was no risk run. The committee further considered it was undesirable to discountenance local enterprise, and Mr. Offor who was manager of the Electric Installation Company, was also a very prominent member of the new company. After discussion, the report was adopted.

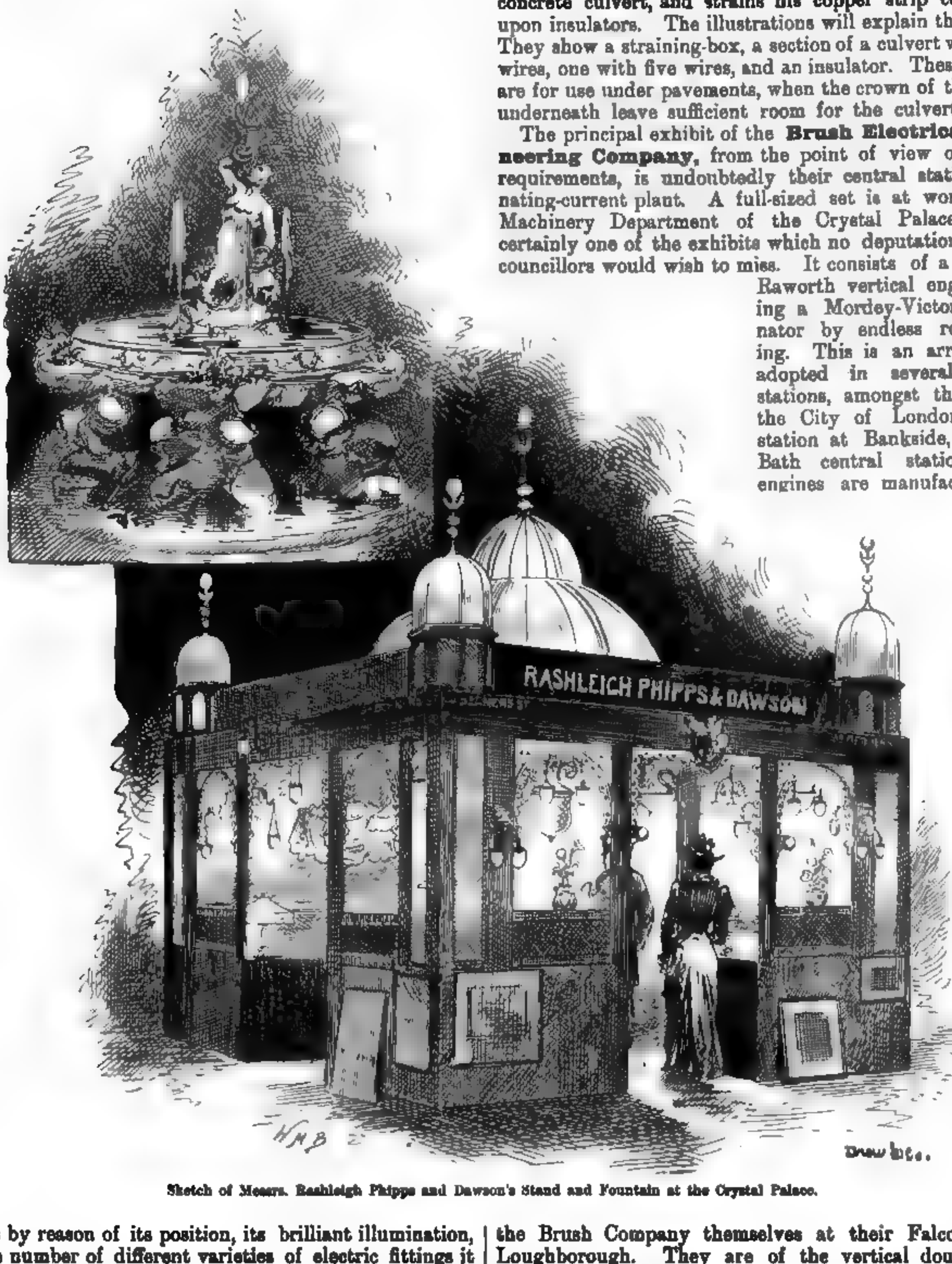
Liverpool.—The Liverpool Watch Committee, at their meeting on Monday, came to the decision to postpone the introduction of electric lighting for public streets. A report was presented by Mr. Boulnois, the city engineer, who had gone most carefully into the subject. After describing the action that had already been taken by the Council, and the results of the experiments that had been made, the engineer embodied in his report the information he had obtained from other towns where the electric light is now in use for public purposes. He presented plans of two areas, one including the whole of the central portion of the city, and the other an equally central but considerably smaller section. In the consideration of this subject two things had to be considered: first, the increase in the illuminating power, and, secondly, equal illumination at a reduced cost. The engineer explained the best mode of electric lighting now available, and compared it with the illumination of the streets by gas. In the larger area the cost annually would be £9,858, whereas the present cost of lighting the same is £3,863; but the estimated cost of the electric light includes the whole of the expenditure on the insulation, as well as interest on sinking fund and all initial charges. After discussion, a resolution was passed that the Watch Committee are of opinion that, having regard to the conditions of rapid development to which the system of electric lighting is now subject, it is not at present advisable to adopt the system. A copy of the city engineer's report is to be sent to each member of the Council.

Waterford.—A serious crisis threatens the electric lighting interest in Waterford, if we are to believe the *Waterford News*, which takes up the question very warmly in a leader, from which the following is taken: "We have heard it whispered that the Lighting Committee are recommending the acceptance of a tender from the gas company for the supply of the public lighting of the city at the rate of £2. 10s. per lamp, or just £1. 5s. less than was paid when this illuminant was in use before in our streets. This will entail the abolition of electric lighting in the city. The step is a very serious one, and we fear it has been resolved on without mature consideration. When the Corporation went to Parliament seeking a provisional order for the right to light the city by electricity, it was the general impression that immediate steps were to be taken to procure the plant, and have the lighting carried out under the control of the Council. In obtaining the provisional order close on £200 of the public money was expended. How can this expenditure be justified if, a fortnight after the granting of the looked-for order, a decision to revert to the worn-out system of lighting by gas is resolved upon? We are mystified. The public will want a very full explanation. At the present moment we see almost every city and town in the United Kingdom substituting electric light for gas. In London, Dublin, Belfast, Limerick, Londonderry, Newry, Kilkenny, and even in Carrick-on-Suir movements are afoot to adopt the more modern system of lighting. The electric light has been established by the local authorities in Carlow. In Dublin gas is but 3s. 6d. per 1,000ft., yet the Corporation have decided to do away with it for the lighting of the streets. We (Waterford) were the pioneers of electric light in Ireland. Are we now to be the first to go back to the customs of olden times? The question is one which the citizens have every right to insist shall not be decided in an offhand manner. There is no time," adds the *News*, "to be lost, for, if all we hear is true, the committee have their report cut and dry for the approval of the Corporation." The promoters and representatives of electric lighting will have to bestir themselves actively, and the complete rout of the gas interest in Larne recently should give them a powerful lever on their side.

THE CRYSTAL PALACE EXHIBITION.

Statistics are ofttimes hard convincers, and it may be so in the case of the numbers who have up to date visited the Exhibition. Compared with the corresponding period of the exhibition 10 years ago, we are told that to the end of last week the numbers were greatly in favour of the present year—that, in fact, 41,000 more visitors have gone to the Palace than at the previous exhibition.

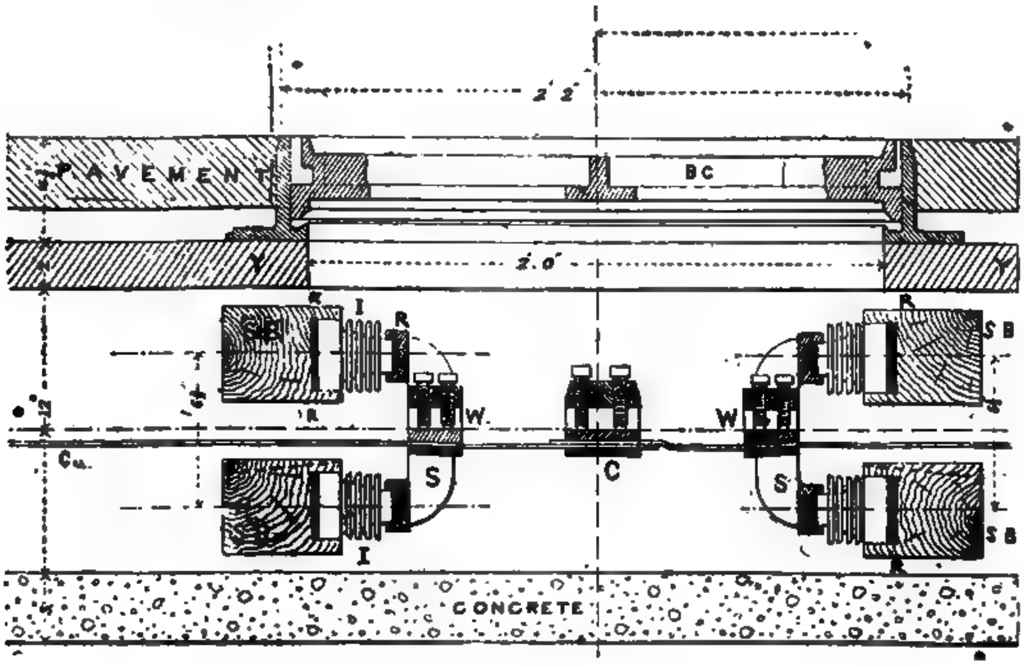
The central kiosk of **Messrs. Rashleigh Phipps and Dawson** attracts a large amount of attention from all visitors by reason of its position, its brilliant illumination, and the number of different varieties of electric fittings it contains. Some hundreds of lamps are lighted, and visitors are able to enter and inspect them at close quarters. The kiosk is always filled with admiring crowds, and the fountain in the centre, surmounted by a high-power lamp, gives a cool *al fresco* feeling to this noticeable exhibit.



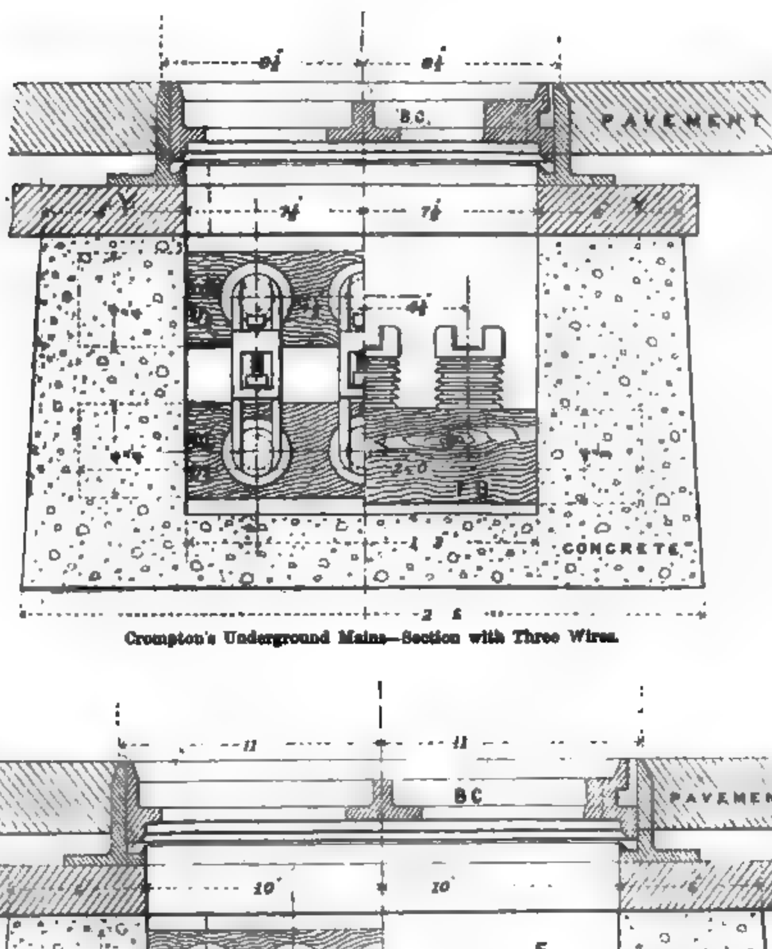
Sketch of Messrs. Rashleigh Phipps and Dawson's Stand and Fountain at the Crystal Palace.

The Machine Department may now be termed complete. We have arranged for a series of critical articles in each department—that is to say, on dynamos, on steam engines, on gas engines. Each set of articles will be contributed by an expert, and should, so to speak, determine the practice of to-day. Meanwhile, we may continue our ordinary description. Immediately on entering the Machine Department we come to **Messrs. Crompton and Co.'s** exhibit. For the sake of those who are not constant readers of this paper we may reproduce some of the illustrations of the Crompton system of mains, so fully described in vol. vii. The example shown at the Palace on one side shows three conductors; on the other side five conductors, representing the previous three-wire system and a pair of feeders. The Municipal Engineers, who visit the Palace to-morrow, will be well able to determine the value of the system as interfering with streets or pavements. Mr. Crompton makes a concrete culvert, and strains his copper strip conductors upon insulators. The illustrations will explain themselves. They show a straining-box, a section of a culvert with three wires, one with five wires, and an insulator. These culverts are for use under pavements, when the crown of the cellars underneath leave sufficient room for the culvert.

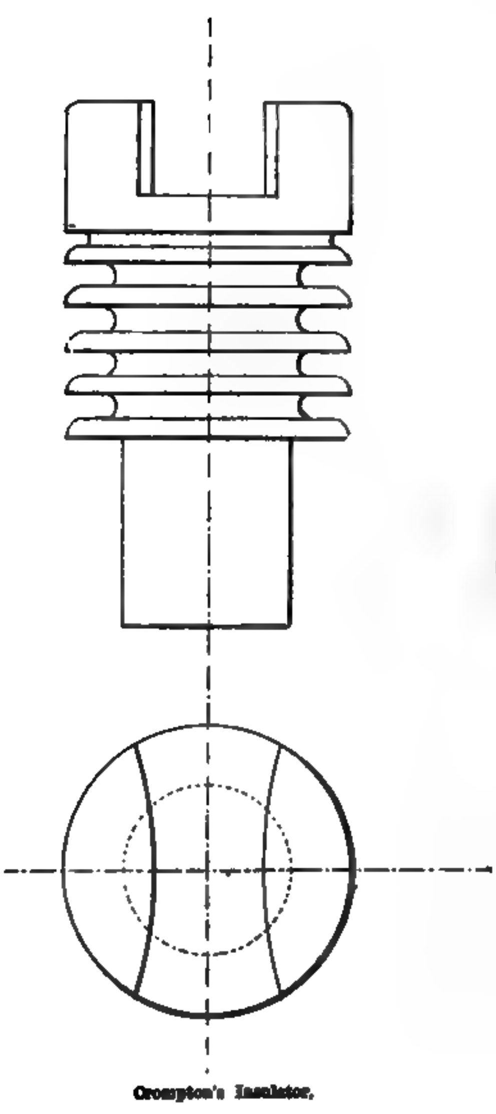
The principal exhibit of the **Brush Electrical Engineering Company**, from the point of view of present requirements, is undoubtedly their central station alternating-current plant. A full-sized set is at work in the Machinery Department of the Crystal Palace, and is certainly one of the exhibits which no deputation of town councillors would wish to miss. It consists of a 280-i.h.p. Raworth vertical engine, driving a Mordey-Victoria alternator by endless rope gearing. This is an arrangement adopted in several central stations, amongst them being the City of London central station at Bankside, and the Bath central station. The engines are manufactured by the Brush Company themselves at their Falcon Works Loughborough. They are of the vertical double-acting marine type, occupying the minimum of floor space, usually a matter of great importance in large towns. The speeds are sufficiently low to avoid undue wear and tear, while high enough to allow driving without countershafting. Special attention has been paid to the design of the lubricating arrangements, and these engines can be run continuously for days or weeks together if needed. A highly sensitive governor is provided, capable of adjustment to control within 2 per cent. It is furnished with two belts, so that the failure of one will not allow the engine to race.



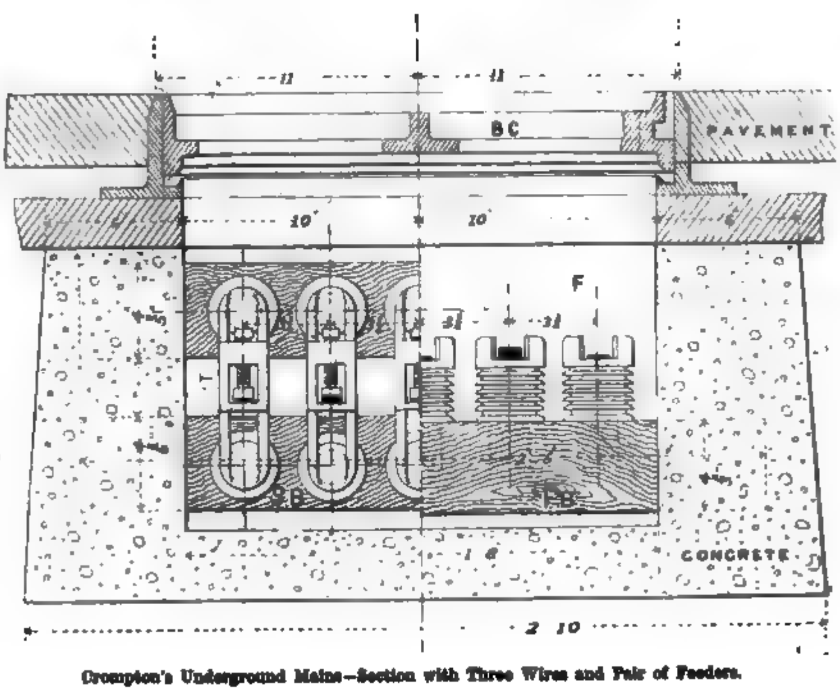
Crompton's Underground Mains—Straining Box.



Crompton's Underground Mains—Section with Three Wires.

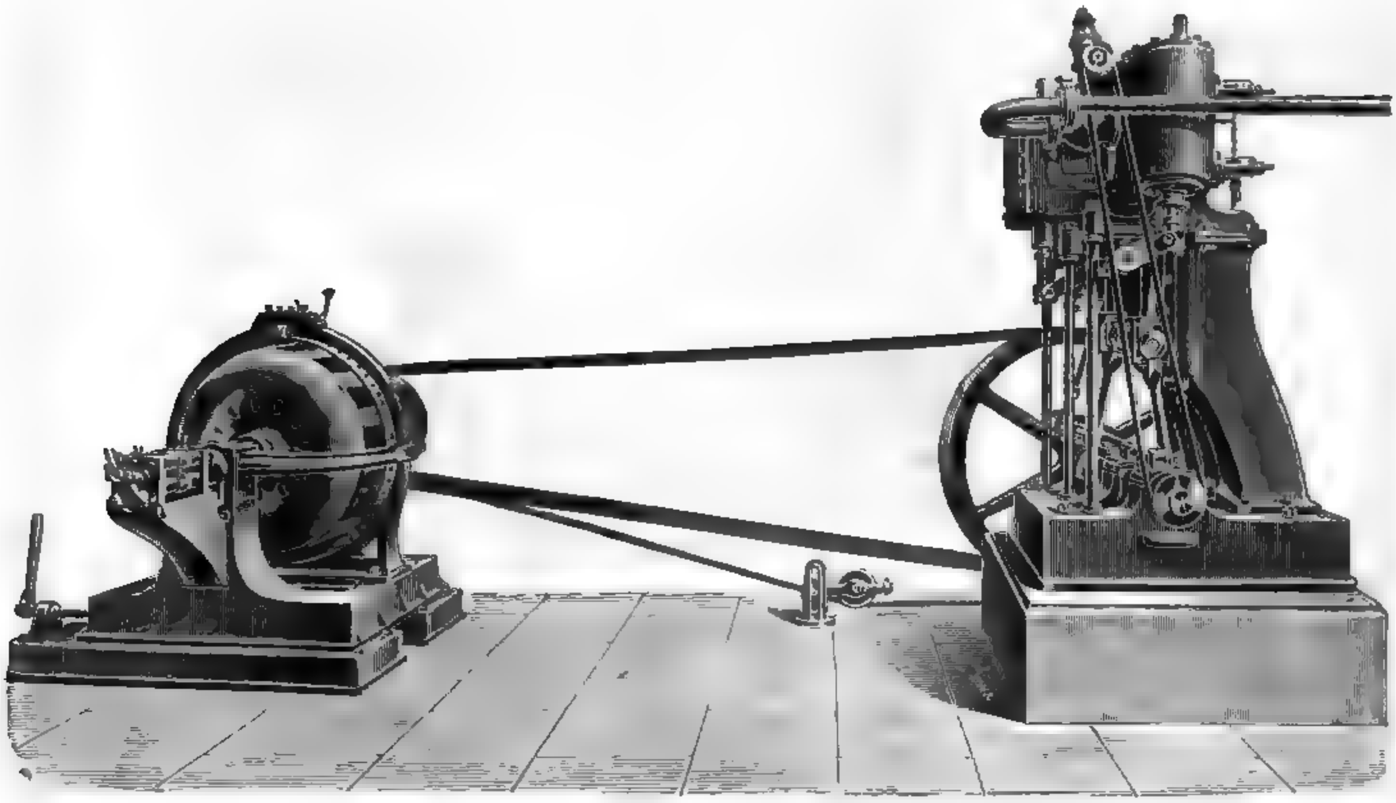


Crompton's Insulator.



Crompton's Underground Mains—Section with Three Wires and Pair of Feeders.

The Brush Company mostly employ endless rope gearing for driving their central station dynamos. A single cotton rope is passed usually eight times around the engine fly-wheel and the dynamo pulley, with what is termed a jockey pulley, suitably fixed for tightening, and to carry the cross-over rope. This arrangement is practically noiseless, and allows the use of shorter driving centres than is permissible with belting.



The Brush Company's Mordey-Victoria Alternator and Engine with Endless Rope Gearing.

The Brush Company's Combined Engine and Dynamo.

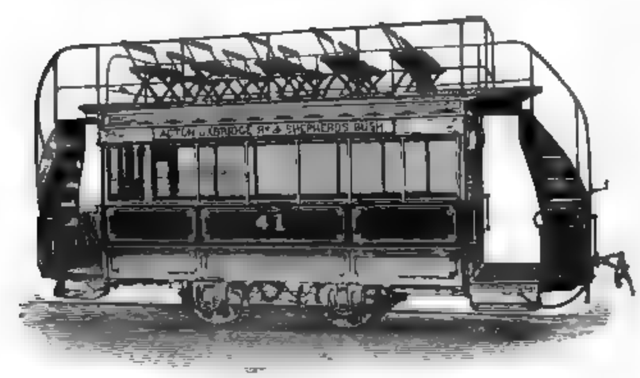
The alternator is of the well-known Mordey-Victoria type, which possesses several features distinct from other alternating-current machines. In the first place, it is very *reliable*, comprising fewer working parts than any other machine of this class. The armature is stationary, and is thoroughly insulated. It is so arranged as to be readily got at for repairs, and in the event of a coil giving way a new one can be inserted with the minimum of trouble. A further advantage is that no brushes or rubbing contacts are required, the mains being connected direct to two terminals. The field magnet is of a simple form, and has the advantage, if required, of only one large exciting coil, instead of a large number of separate coils. By revolving the field magnets instead of the more delicately constructed armature, safety in running is assured, while the weight of the field magnets act as a flywheel to keep

the speed steady. An important feature of this alternator is that although its highest efficiency is reached when fully loaded, yet it works very economically with light loads—a point of great weight in central station work. These dynamos work admirably in parallel, so that where, as in town lighting, the load varies continually, extra machines can be switched on with safety. This enables any circuit to be fed with one, two, or three dynamos, so that the machinery can be thrown in as desired, and in the event of one dynamo or engine having to be stopped, the others can continue without causing

The Brush Company's Transformer.

variation in the light. A unique feature of these machines is that the armature is entirely visible during running, and may be examined then or at any other time without the necessity for removing any portion of the machine. It is fully accessible for the purpose of cleaning or repairs without the removal of any part of the machine. The alternator shown is of 100,000 watts, capable of lighting about 4,000 8-c.p. lamps.

The standard switchboard used in the Brush alternating-current stations is simple and efficient. All the alternators



The Brush Company's Tramcar.

feed into a pair of "omnibus" bars or common conductors, and all circuits are supplied directly from these bars. Each alternator is provided with a standard switchboard, on which are all instruments and connections required, placed behind a locked glass door. The only exterior parts are the switch handles attached to gut bands passing through the lower casing. This prevents all possibility of accident, and renders the manipulation exceedingly simple. When a station is started, a standard board is provided for each existing dynamo and one for each circuit. As further machines are added an additional switchboard is inserted. In this way there is no necessity for providing specially designed switchboards. Future requirements, however extensive, fall naturally into the same system without difficulty or complication.

The Mordey-Victoria transformers used on the Brush system for reducing the high electric pressure generated at the station to a pressure suitable for the house supply, are of simple form. As with all transformers, they consist essentially of two windings of insulated conductor arranged with reference to a mass of iron, so that the high-pressure currents entering one coil induce low pressure currents in the second coil. The design aims at economy of construction, accessibility for repairs, thorough lamination, good ventilation, and high efficiency at all loads. For interior use the transformer is mounted in a simple manner without special protection. They can be placed on a shelf or on wall brackets out of reach. For exposed positions the transformer is made weather-proof, and mounted on iron castings, fitted internally with high-tension fuse and switch.

One of the exhibits which always attracts a large share of attention from technical and non-technical visitors alike is the row of Brush combined engines and dynamos, which, with "no visible means of support," are continually merrily working away as if in regular action. These are driven, there is perhaps no need to explain, by the dynamos working as motors; but the engines in running order, coupled to Victoria incandescent machines, make a striking show, and have, as we happen to know, resulted in many enquiries for this kind of plant.

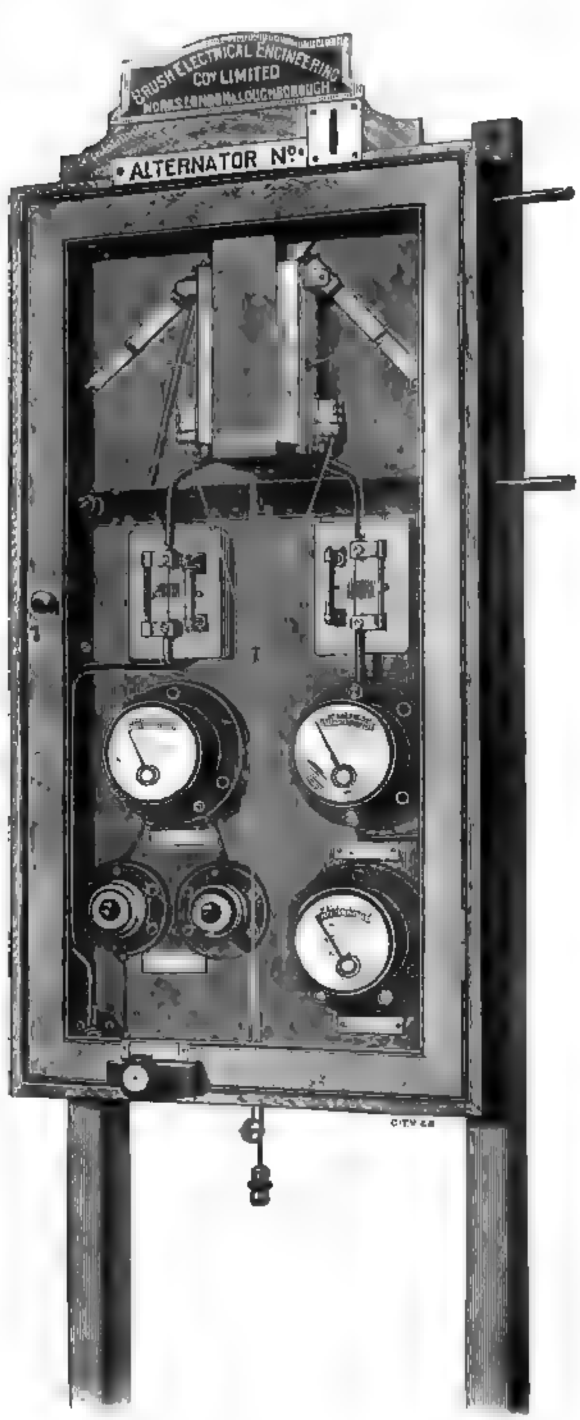
The beautifully-made tramcar, constructed by the Brush Company at their Falcon Works, makes also a splendid exhibit from the spectacular point of view, and illustrates the kind of car the company would provide when orders for electric tramcars are given to them.

THE RIES REGULATING LAMP SOCKET.

BY WILLIAM J. HAMMER.

One of the most interesting and ingenious appliances exhibited before the convention of the National Electric Light Association in America, at its Montreal meeting last summer, was a form of lamp socket devised by Mr. Elias E. Ries, of Baltimore, Md., U.S.A., for controlling individually the candle-power of incandescent lamps upon alternating circuits. In view of the widespread interest which this invention has attracted in America, and its great commercial value in electric lighting by alternating currents, and, furthermore, in view of the installation now being made at the Crystal Palace Electrical Exhibition of the first Ries

appliances shown on this side of the water, a few words upon the subject of controlling the candle-power of incandescent lamps in general, and particularly by this appliance, may prove of interest.



The Brush Company's Alternating Switchboard.

Many attempts have been made to produce a satisfactory and economical method of turning down incandescent lamps. The earliest experiments which were made by Mr. Edison and others, and in which carbon rods, plates, coils of German silver, platinium, iridium, and other metals were introduced in series with the lamp, thus causing considerable of the energy cut out of the lamp to be dissipated as heat, proved inefficient or of little commercial value.

Lamps were also constructed containing two or more carbons, which could be connected in series or multiple, to vary the candle-power, and a lamp invented by the writer many years ago contained a number of carbons of various candle-power, which could be separately introduced into the circuit to give any degree of light desired.

Inventors have also endeavoured to construct an economical device for controlling the light without the introduction of resistance, as the value of such a means of *regulating* the incandescent light has always been appreciated, and one of the principal claims of gas engineers is that the incandescent lamp could not be turned up and down, certainly not with the efficiency which existed in the gas system.

Mr. Philip Diehl, of Elizabeth, N.J., has presented the author with a complete set of the experimental steps in his alternating-current lamps, which show a very interesting stepping-stone in this direction. Before proceeding further let me say a few words upon the principle of the reaction coil which has been applied in various ways by Prof. E. Thomson, Shallenberger, Ries, and others, and referred to in the works of Fleming, Hopkinson, and others. A reaction coil of the most simple type is constructed of one coil of a conductor wound round a magnetisable core—probably the simplest form employed commercially is the ordinary spark coil used in electric gas lighting.

A direct current passed through such a coil magnetises the core and sets up lines of force which maintain the same direction so long as the current is continued; there is a slight heat also produced in the coil due to its ohmic resistance. Naturally, reversing the direction of the current reverses the polarity of the magnetised core. It does, however, more than this. This reversal of current, and consequent disturbance of the magnetic field, produces practically a transformer with but one coil, in which appears the impressed E.M.F. and the counter E.M.F. The counter E.M.F. retards the primary current through the coil, producing the "choking effect," as it is termed. In employing a continuous or direct current the counter E.M.F. is produced only at the instant of closing of the circuit or reversing the direction of the current, but with rapid alternating current the counter E.M.F. becomes as constant as the impressed E.M.F. of the primary current, and in the Ries socket the ratio of these may be varied, thus controlling the candle-power of each light independently and without resistance, and, as shown by Fleming and others, with an infinitesimal loss.

When the difference between the two E.M.F.'s is greatest, as determined by the position of the regulating key, the light is at its maximum, and when this difference is such that the two E.M.F.'s nearly approximate each other, the filament glows at its minimum point of light. One of these E.M.F.'s being variable with respect to the other, it will thus be seen that lamps of any desired voltage less than that of the supply circuit can be safely burned at their normal candle-power, and that standard lamps of any given voltage or resistance that are supplied with a normal E.M.F. of, say, 50 or 55 volts, can be burned at any degree of brilliancy required all the way from a barely perceptible glow up to their maximum candle-power. The most remarkable part of this method of electric lighting is its extremely high efficiency and the self-contained simplicity of the apparatus by which it is carried out. The writer has in his possession sockets of this character in which the two E.M.F's so nearly balance each other as to extinguish the light without even the necessity of opening the lamp circuit, the amount of energy consumed in maintaining this balance being so slight as to be measurable with only the most sensitive instrument. I have personally placed lamps in series with a sensitive ampere-meter, and varied the current from $3\frac{1}{2}$ amperes to $\frac{1}{10}$ of an ampere, as perfectly as gas is turned up and down, the ampere-meter indicating the variation in current precisely as if it were a fluid or gas which was being turned on or off.

The writer has had the privilege of witnessing some ingenious and beautiful effects produced by Mr. Ries, which show the facility with which this socket lends itself to modifications, adapting it to special requirements. For example, one is enabled to operate a 110-volt Edison lamp on a 55-volt Westinghouse alternating circuit, or to operate a 55-volt lamp on a 110-volt circuit, at the same time to produce all the variations in light from nothing up to full candle-power. All this, it should be noted, is produced with practically no loss of current, and entirely by the reaction of the current upon itself—no moving apparatus or outside connections whatever, other than the usual circuit adjustments on ordinary lamp sockets, being employed.

A very good idea of the general appearance of the Ries regulating socket, as at present made, may be obtained

from the accompanying illustration. The socket comprises an enclosing shell of neat design, and but slightly larger than the well-known types of "make and break" sockets now in use, and contains a small counter E.M.F. generator, or reaction coil, or choking coil, of peculiar construction, which, however, may be of any desired type so long as the general conditions to which it owes its high efficiency are adhered to. In the type of socket illustrated, this coil consists of a small, thoroughly laminated, closed iron core built up of numerous rings of specially prepared iron, the whole being compressed, taped, and wound at one operation with a special silk-insulated cable containing a number of separately insulated copper wires of different diameter, varying according to the maximum current to be carried by each, the ends of these wires, after the cable is wound, being connected in series with each other by contact-pins arranged in the path of an arm attached to the operating key. The interior connections are such that, when the socket is wired up, more or less of the wire composing the coil is in series with the lamp filament, according to the position of the operating key, and the length of wire thus included determines the amount of counter E.M.F. generated, or to express it in

The Ries Regulating Socket.

another way, by cutting out turns of the coil the self-induction is lessened, and more current is allowed to flow through the wire to the lamp. The light is divided by this socket into seven different stages, and the potential difference between each contact-pin being but one-seventh that of the total difference of potential on the mains, the flashing at these points is very slight, no snap action or other complicated make and break mechanism being employed. The entire arrangement is one of great simplicity and compactness, requiring no more attention and knowledge in operation than the turning on and off of an ordinary gas burner, which in this respect it closely resembles.

When the lamp is burning at full candle-power practically all of the coil sections are cut out—that is to say, when lamps of the normal voltage of the supply circuit are used. Usually, however, it is advisable to employ lamps of somewhat lower voltage, so that if for any reason the pressure on the circuit falls below its normal, the lamp may be turned up so as to still give its maximum candle-power, a feature not at present attainable with the ordinary type of sockets in general use. When the full amount of light is not needed, the counter E.M.F. generated is increased by the cutting in of additional coil sections, thereby reducing the flow of current through the lamps and causing the latter to glow at a lesser degree of brilliancy, and at the same time materially reducing the strain upon the lamp filament. The winding of the socket is so arranged that when the light is turned down to its lowest stage, the filament is just visible in the dark, so as to readily enable one to locate the position of the lamp upon entering the room and to turn it up to the desired point without having to first feel around for it among the electroliers or other fixtures of which it forms a part. By the use of this socket one may have some lights in a room burning at low brilliancy and others at a lower degree of incandescence, thus distributing the light exactly where it may be wanted, instead of being compelled to burn the lamps full on when little light is needed. The direct effect of this method of regulation is that, with a given expenditure for current, the average number of lamps in use may be largely increased, and the fact that it is thus possible to burn the lamps at a lower glow, and consequently at a reduced average cost for current and lamp renewals, especially in rooms, hallways, and other places that may be partially or entirely unoccupied for hours at a time, will lead to a very much more extended use of the incandescent electric light than it has hitherto enjoyed, and at the same time open up to electric lighting stations a great deal of new and profitable territory which is now beyond their reach. The saving in current that this socket is capable of effecting is almost beyond the belief of one who has not tried it, and actually surpasses everything that has yet been claimed for it in this direction. The writer has had occasion to thoroughly investigate this point recently, and has found that a 25-c.p. 50-volt lamp which consumed 75 watts when burning in one of these sockets at full candle-power consumed, together with the socket, just three watts, or only $\frac{1}{25}$th of the total energy, when burning at a low degree of incandescence equal to that produced by a net potential difference of 10 volts at the lamp terminals. This means that it is possible to burn 25 lamps at a visible degree of incandescence by means of this socket with the same amount of electrical energy that a single lamp would consume burning at its normal candle-power. Of course, the light given by the lamp at this point, while sufficient to render the filament of the lamp visible at a distance, was altogether too small for the purpose of affording outside illumination, and therefore this cannot be taken as a criterion of the average consumption of current in practice, which would be very much higher, especially as the lamps are usually burned at nearly full candle-power by the consumer when in actual service for furnishing light, the intermediate stages being used, for the most part, only for all-night service in sleeping apartments and other places where under the existing condition of things the incandescent light, if used at all, would be turned off altogether.

In conclusion, I would call attention to the fact that while the sockets shown at the Crystal Palace are only slightly larger than an ordinary Edison socket, they may be made considerably smaller where the rate of alternation is increased.

Douglas (Isle of Man).—Tenders are required for maintaining an electric light installation at Falcon Cliff Grounds, Douglas, Isle of Man. Full details can be obtained from Mr. Rowe, secretary, Cliff Company, Douglas.

Accumulator Tests. — Prof. Henri Dufour, of Lausanne, has been making tests with a number of storage cells with perforated plates. He gives the following results of his tests with reference to the ratio of capacity with weight: Huber accumulator (manufactured at Marby, Switzerland), 14·6 amperes per kilogramme (2·2lb.); E.P.S., 7 amperes per kilogramme; Reckenzaun, 7·2 amperes per kilogramme; Farbaky et Schenk, 11·2 amperes per kilogramme.

THE

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EDISON.

Advices are gradually reaching us that in the financial games as played across the Atlantic, Edison has met with a reverse. The wire-pullers of the Thomson-Houston interests, according to all accounts yet received, have scored a decided and probably a decisive success. The result is attributed to enemies at home. Trusted friends and comrades of Edison, it is hinted, have played their own hand and left the master's interests to the care of nobody. It has been our misfortune on more than one occasion to sharply criticise actions, financial and otherwise, taken, or said to be taken, on behalf of Edison; but we never expected to have to record his detriment through a trusted comrade. From first to last, so far as our history of Edison and his financial work goes, we have invariably found him putting his assistants into positions wherein they might make money. Not one or two, but numbers, have been able by their connection with him to rise from poverty to affluence. We have heard similar things said of Colonel North—that he never forgets his friends. Similarly Edison. If the interests of Edison have suffered because of the mismanagement of one or more of his trusted colleagues, it is a matter, in its personal aspect, to be deeply regretted. No doubt, boom upon boom has hitherto been consummated by a dexterous use of his name. The public have parted with large sums of money that have gone into the pockets of the schemers. From this point of view a possible good may arise. The public will be less prone to follow the calls of the charmers than when the position seemed unassailable. Edison has done good work, not altogether in the direction in which he is publicly accredited—so have other people; and this reverse will enable a more correct estimate to be formed of the true value of his work than has been previously possible. So far as we can gather, Edison has not believed in very high pressures. The systems he has devised have been with low pressures, and it must never be forgotten that he started from the earliest period of his lighting work with the view of designing a complete system of distribution. He studied carefully each link in his scheme, and though it was at first admittedly imperfect, it was a complete system. Without entering into any question of Swan *v.* Edison, we may be allowed to quote a sentence embodying the view above mentioned—a sentence written many years ago by one interested in Edison: "But it must be remembered that even if Mr. Swan's patents were for a lamp . . . his patents would still amount to nothing unless he had also invented and patented a comprehensive system of using them." We presume Mr. Lane Fox is at present fighting to show he designed a system in 1878; but this case being still undecided we must refrain from any comment. We trust, however, that it is not contempt of court to point out that Edison, and Edison only, proceeded at once to carry out his system upon a large commercial scale. Other inventors designed machines, or lamps, or cut-outs, or switches, but no one at that time troubled about a "complete

system." Although Edison may in this game of finance have met with a reverse, it is not to be considered for a moment that he will fail to hold a leading position in America as he hitherto has done.

THE CHATHAM ACCIDENT.

One of the most astonishing, although at the same time one of the most deplorable, accidents that have occurred in the history of electric lighting, is that recorded during the past week as having happened at Chatham. That a man, however ignorant, should have the temerity to meddle with an electric light circuit while the current is on is hardly conceivable. It is just as if a man thrust a burning brand into a gunpowder barrel and expected no harmful effects to follow, though perhaps most would place it on a par with seeking for a gas escape with a lighted candle. It is foolhardiness of this kind that brings discredit upon any industry, for there is no protecting the man who wilfully puts himself into a dangerous position. Still, this accident will have one good effect. It will cause engineers to ask if yet further precautions are not possible to prevent any man tampering with a dangerous wire in a house—in other words, is it necessary to have a wire carrying current under a dangerous pressure in the house at all? We are not going to specially discuss the Chatham case, but to take a wider view. That danger must exist at some point to meddling hands is true in almost every industry, and precautions are taken against hands meddling. Machinery is guarded, and henceforth high-pressure terminals, mains, or wires must be guarded. In series arc lighting wires are usually out of reach, but even in these cases notices may be conspicuously posted, cautioning anyone against touching wires while the current is on. In low-pressure work the present precautions seem ample, while in high-pressure work this accident points to the modification urged by many eminent engineers—no transformers in the house. If under no circumstance a current over a hundred volts pressure be brought into a house, it is difficult to imagine where danger can come in. Even in the transformer station there ought to be little difficulty in guarding the primary terminals and circuit from anything but wilful contact. At the present time a large number of switches ordinarily used are condemnably bad, and liable to lead to accident. Hardly any householder has a perfectly safe means of cutting off the main circuit, presuming the transformer in the house. A lambent blue flame playing across the contact would frighten everybody away from the switch, and no other way is provided for breaking the circuit. The handle of a switch, instead of being three inches away from the arc, might for the matter of that be thirty feet away, and the most timid would not mind turning the handle at that safe distance, although they would have too much respect for their fingers to touch the ordinary short handle. This is not a suggestion—it would be ludicrous to insist upon thirty feet of handle—but what must be insisted upon is the necessity of providing some method of breaking the main circuit that shall be absolutely safe under all circumstances.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

CRYSTAL PALACE EXHIBITION.

SIR,—Were you ever electrified? When next you go to the Electrical Exhibition at the Crystal Palace you should be. A few days ago a friend (?) persuaded me to get into that awful chair, and as soon as the thing began to go the sparks flew, and I was tortured with a metal brush and a stick of charcoal until the hair of my head stood on end "like the quills upon the back of the fretful porcupine." Oh, sir, if ever I——. Well, you try it, and if you survive you will probably feel as lively as the great American baboon of Rangoon that fell out of a palm tree on to the head of Sir Isaac Newton. Hence the discovery of greased lightning.—Yours, etc., X.

A DESCRIPTION AND COMPARISON OF THE METHODS OF ELECTRIC LIGHTING AT PRESENT IN USE IN LONDON.*

BY ALEXANDER B. W. KENNEDY, F.R.S., M.I.C.E., ETC.

(Concluded from page 231.)

Fig. 5 shows the arrangement of mains which I have adopted in my own district. It may be rather called a double two-wire than a three-wire system, and has enabled me to make a very great saving in copper, as compared with the ordinary three-wire distribution.

The Chelsea system, to which I have alluded, is one which General Webber has again lately described in detail before the Institution of Electrical Engineers, and which possesses much special interest. A single central station distributes continuous currents, at a pressure of from 500 to 1,500 volts, to a number of battery stations scattered through the district. The current does not go direct to the consumers at all, but goes entirely to charge accumulators. The pressure is maintained by charging the cells in series, either in one station or in several simultaneously. After being thus charged, the cells are discharged in parallel, so that each set gives a discharging current of about 100 volts pressure. The batteries are so arranged that one part is always delivering the current to the circuit, while the other is being charged, until the charge is complete. The leading advantage of this system, a very great one, is that the load on the engines is more or less independent of the fluctuation of customers' demands, and is therefore steady and fairly heavy while it lasts, so that the engines can work with considerable economy. The drawback is, that the whole of the current has to pass through batteries, which means, at the very least, a loss of 15 per cent., and probably more nearly 25 per cent. in energy, besides all the other losses in the mains, etc. Time only can show on what side the balance of advantage lies.

In order to supplement the batteries at times of the heaviest loads in winter, when in London day is turned into continuous night, and when therefore the charging can hardly overtake the discharging of the cells, the use of what are called continuous-current transformers has been commenced. A continuous-current transformer is simply a combination of a motor and a dynamo, so arranged that the motor part can be driven by a current of 500 volts pressure while the dynamo part gives out, like the batteries, a current of 100 volts pressure. This apparatus is an exceedingly interesting development in electrical engineering of which we are certain to hear more.

In conclusion, you will perhaps like me to say a few words about the cost of electric lighting in houses and

* Reprinted from the *Transactions* of the Royal Scottish Society of Arts, vol. xiii., part 1. Read May 11, 1891.

streets, as this is a matter which may very soon affect you closely in Edinburgh. Street lighting is a matter I have not mentioned yet, because there is as yet none in London, although the City itself is shortly to be lighted by a recently formed company. About public lighting the point to be remembered is, that in the streets people are not content with electricity unless it gives them 20 to 25 times as much light as they are getting from gas. Under these conditions it will cost at least four or five times as much as gas, and quite probably more. Light for light it will not cost more than about a quarter the cost of gas, and in any given case a community has simply to make up its mind whether it is worth its while to pay extra, although at a cheaper rate, for a very much better commodity.

As to private lighting, however, the figures are very different. Here the cost depends to a very great extent upon the amount of common sense which has been used in the wiring and lighting of the rooms and the amount of care which the householder is willing to exercise. If each light in a room has a separate switch, so that lights can be added as required, one at a time—if the lights are not covered up tate an expenditure of double or treble the current at an exactly corresponding increase of cost.

I try to put this very clearly in order that there may be no disappointment later on—at least, so far as I can obviate it—with the bills which will come in from your electric lighting company. Let me emphasise one point still more. If the electric light had to be left on in unused rooms as gas is left on, its cost would be twice as much as that of gas. It can only be brought down to the figure I have named by adopting rigidly the plan of turning it out always on leaving the room. With electricity this is so small a matter that practically it is no trouble whatever.

As to hotel and club lighting, where the same economy cannot be practised, and where, above all, the proportionate number of lights on at one time is always much greater than in a private house, the cost of electric light, even with all the economy possible, will hardly be less than double that of gas at 3s., supposing the electric light to be charged at the rate of 8d. per unit.

For shop lighting no figure can well be given, for the simple reason that the owners of shops generally use the light partly as an advertisement or attraction, and therefore

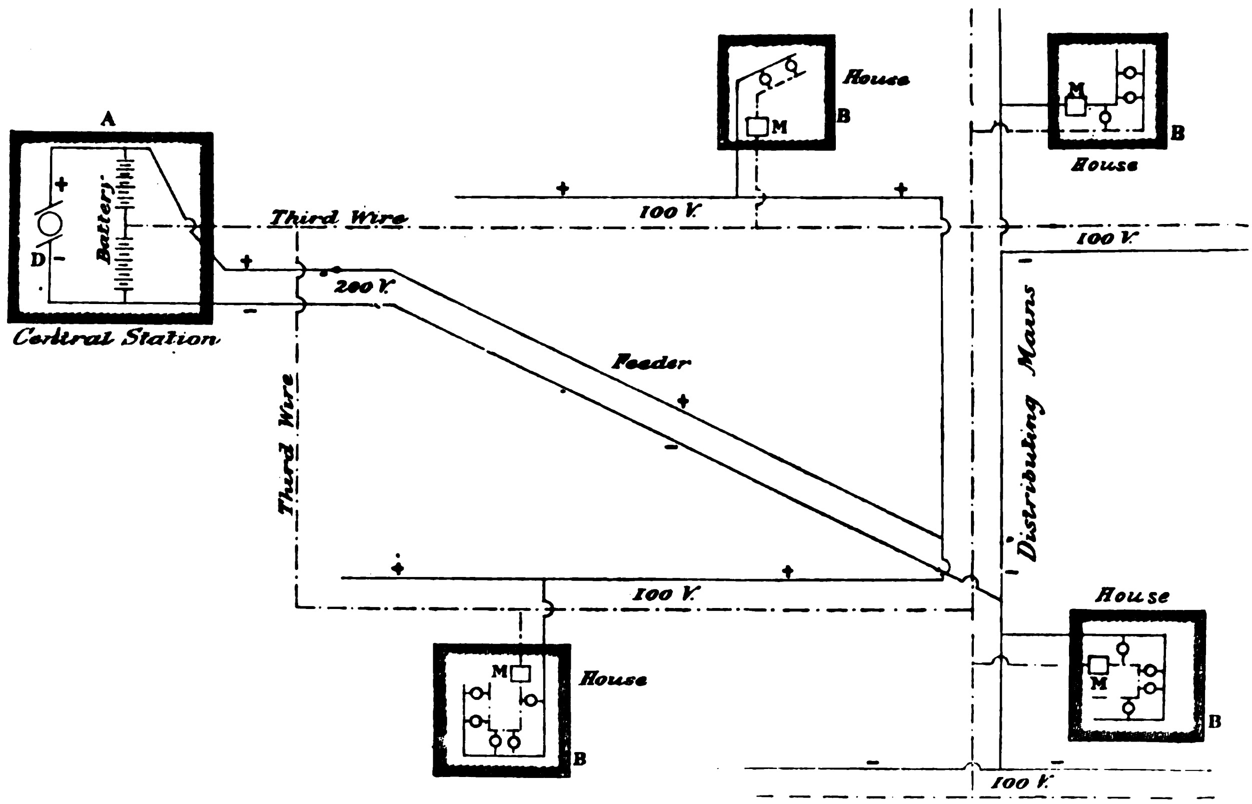


FIG. 5.

and darkened with frosted or iced or opal shades or glasses, which may be pretty, but which certainly absorb from 40 to 70 per cent. of the light; if people are content to replace 5-c.p. gas burners with 8-c.p. lamps, and do not insist on 16's; if every room has one switch placed just inside its door so that it can be turned directly the door is opened, then the cost of lighting a private house with electricity will probably be about 25 per cent. in excess of gas, if gas is 3s. per 1,000 cubic feet, and electricity 8d. per unit. Here, where I am told that gas costs 4s. 6d. per 1,000 cubic feet, there is no doubt that a private house can easily be lighted well with electricity at a less cost than with gas.

But it must be clearly understood that this estimate of cost does not apply if the house is so wired that two or three lights have often to be turned on when only one is required, or if the switches are so placed that it is inconvenient to get at them in the dark, so that the light is left on when the room is empty instead of being always turned out; or, worst of all, if the house mistress think "the little wire in the lamp," as she calls it, a detestable object, and insists on disguising it by ornaments, which absorb the greater part of the light generated, and therefore necessi- use very much more than there is the least occasion to use, finding no doubt, as they are the sole judges of what is good for their business, that it pays them to do so.

Actually the cost of electric lighting is known with great exactness to be a farthing per hour for an eight-candle lamp, and a halfpenny per hour for a 16-candle lamp, when the charge for current is 8d. per unit. On this basis any one can make out beforehand the exact cost of burning any number of lamps for any known number of hours.

My remarks have already extended to such a great length that I will not say anything about the light from the points of view of health, comfort, cleanness, coolness, and general convenience. No one who has ever tried it has ever expressed the least doubt on these matters, and they have for long been practically beyond question.

I can only conclude by expressing the hope that here in Edinburgh you may soon be able to verify for yourselves the universal opinion of those who use the light, and I shall be exceedingly glad if my remarks this evening have any influence whatever in helping forward the movement in which I understand your Town Council is already taking the first steps for supplying the city of Edinburgh with the electric light.

AN INTRODUCTION TO QUALITATIVE CHEMICAL ANALYSIS.

BY BARKER NORTH, ASSOC.R.C.SC. (LOND.),
Joint Author of "Introductory Lessons" and "Hand-book of Quantitative Analysis."

(Continued from page 162.)

Microcosmic Salt Beads.

A bead of fused microcosmic salt reacts in a similar manner to borax when heated with a few metals, and is therefore of great value in obtaining a knowledge of the composition of a substance.

How to Make a Microcosmic Bead.

This is done in the same way as in making a borax bead, but as microcosmic salt froths up a good deal on heating, a very small portion must be taken up at a time till the clear bead is of the proper size and quite free from bubbles. It is much more difficult to keep a bead of microcosmic salt on the loop of wire than one of borax, and if it gives any sign of falling off it may often be retained by turning the wire round slowly and continuously, or by holding the bead in the upper part of the flame in use.

Reactions Observed: Colour of Beads.

The reactions to be observed are similar to those of borax, the colour varying with the flame employed, and also depending on the heat of the bead, whether hot or cold.

Experiment 14.—Heat a salt of copper in a microcosmic bead made as above described, and notice that in the oxidising flame the bead is green whilst hot, and blue to green when cold, but that in the reducing flame it is dark green when hot, and an opaque red after cooling.

Sample Beads.

The student might with advantage make a set of borax and microcosmic beads from the following tables, and preserve them in a bent piece of tubing sealed up at the ends, as in Fig. 5. The microcosmic beads may be put in one limb and borax in the other, a mark being made on the glass to distinguish them. Two specimens of each metal should be kept, one made in the oxidising and the other in the reducing flame, and by taking account of the order in which they have been placed in the tube, they may be used for the recognition of another bead by comparison.

Table of Colours obtained in Borax Beads.

Metal.	O.F.		R.F.	
	Hot.	Cold.	Hot.	Cold.
Cobalt	Blue	Blue	Blue	Blue
Copper	Green	Blue-green	Green	Opaque red
Chromium ...	Yellow	Yellow-green	—	Strong green
Iron........ ..	Red	Yellow	—	Bottle green
Manganese..	Violet-red	Amethyst red	—	Colourless
Nickel	Hyacinth-red	Sherry red	—	Colourless

Table of Colours obtained in Microcosmic Beads.

Metal.	O.F.		R.F.	
	Hot.	Cold.	Hot.	Cold.
Cobalt.........	Blue	Blue	Blue	Blue
Copper	Green	Blue to green	Dark green	Opaque red
Chromium ...	Red	Green	Dark red	Dark green
Iron	Yellow to red	Colourless to brown-red	Colourless to red	Colourless to red
Manganese..	Violet	Red-violet	—	Colourless
Nickel	Red to brown	Yellow to orange	—	Colourless

Flame Colourations.

When salts of certain metals are held on a piece of clean platinum wire in the outer edge of the Bunsen flame, very distinctive colourations are imparted to it, which may be used for recognising the presence of these metals.

Mounting Platinum Wire Used for Flame Tests.

The end of a piece of thin glass rod or tubing is softened in the blow-pipe, and while still melted the end of a thin piece of platinum wire, about 4in. long, is inserted, the two being afterwards fused well together and allowed to cool. In order to keep the wire clean it may be suspended in hydrochloric acid in a test-tube, by means of a cork through which the glass rod is made to pass, as in Fig. 6.

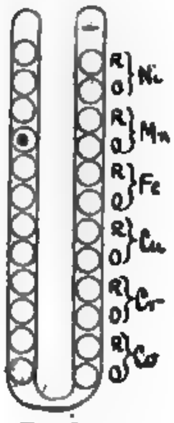


Fig. 5.

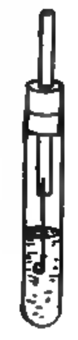


Fig. 6.

The wire should be well cleaned in acid before using, and no colouration must be observed when it is held in the outer edge of the flame, otherwise it is not clean. It is best, too, to take only a very small portion of the substance on the wire at a time, as certain metals, such as copper, antimony, lead, etc., act detrimentally on platinum, and great care should therefore be taken if these have been indicated by the blow pipe reactions.

Experiment 15.—Moisten the platinum wire with hydrochloric acid before dipping it in a sodium salt, and hold it in the outer edge of a Bunsen flame; observe the golden yellow colour imparted to the flame, and also that the light emitted causes the skin of the hand to look quite livid.

Experiment 16.—Now take a little of a potassium salt on the clean wire, and observe the violet colouration communicated to the non-luminous flame of a Bunsen burner.

Experiment 17.—Mix equal quantities of sodium and potassium chlorides and test on the wire as before; the potassium will be quite hidden by the sodium. If, however, a piece of blue glass be taken of such a tint and thickness as to render the strong sodium light invisible, and the flame from the mixed chloride be viewed through it, then the yellow rays from the sodium flame will be absorbed, and only the violet colour due to the potassium will be observed. The blue glass should be carefully tested with a pure golden yellow light from a pure sodium salt to make sure that all the rays from this flame are absorbed.

Experiment 18.—Another way to observe potassium in the presence of much sodium is to bring a little of the substance on the end of a platinum wire moistened with hydrochloric acid very gradually near to a Bunsen flame. The potassium salts being much more volatile than the sodium salts will be vapourised before the substance quite enters the flame, and the violet colour due to potassium will therefore be observed first, the sodium flame afterwards coming out strongly when the substance is brought nearer or into the flame.

Wet Reactions.

When the dry reactions have been carefully gone through, the substance is analysed in the wet way, and as this is the more reliable method, it will be a considerable advantage for the student to acquire manipulative skill in the working out of the reactions and processes of this method before treating of the independent reactions of the various metals.

In analysing a compound in the wet way, we first prepare a solution of the substance under examination, and then by adding other compounds in solution of known composition we observe the effect produced, such as change of colour, formation of a precipitate, etc. In the majority of tests which are applied in the wet way, the result observed will be the production of a precipitate which is simply an

insoluble compound formed by the reaction between the reagent and the substance under examination. In this way, by obtaining from various reagents different coloured precipitates which also have different properties, we are led to infer the presence or absence of any metal.

SOLUTION.

This is the first process to be performed in applying the wet reactions to any substance. We find that many substances, when mixed with water in the solid state, gradually disappear, or as we say dissolve, forming a solution of that substance in water. The liquids which thus cause substances to disappear, or dissolve, are called *solvents*. This is what is known as *simple solution*, as the substance can be again obtained unaltered by evaporating off the solvent. Other liquids, however, besides water may act as solvents; thus alcohol, in many cases, is also a *simple solvent*, and acids, such as hydrochloric acid, may also dissolve certain substances. As a rule, when acids are used as solvents, we no longer obtain simple solution but *chemical solution*, as, in the act of dissolving, a chemical reaction takes place, and, instead of the original substance going into solution, a new compound is formed which is soluble in water. Chemical solution is only used in ordinary analytical chemistry when simple solution in water fails to dissolve the substance.

In some cases it will be found that the compound to be tested is unattacked even by acids, and we may thus fail to dissolve it either by simple or chemical solution; such a substance is called an *insoluble*, and in these cases a different mode of attack has to be adopted.

Experiment 19.—Take a few crystals of lead nitrate and cover with water in a boiling-tube, the latter being simply a large test-tube. Show, by gently warming or by allowing to stand some time in the cold, that this substance disappears, or is dissolved. When a liquid is boiled in a test-tube, the latter will often become too hot to be held in the fingers, and a test-tube holder may be extemporised by doubling up stout paper into a narrow strip and holding it by the ends wrapped tightly round the top of the test-tube.

Experiment 20.—Now put a little carbonate of lime or chalk into water, and show that by warming, or even boiling, the substance remains undissolved. Notice, however, that directly a little hydrochloric acid is added that an effervescence commences, and proceeds till the solution is quite clear and the chalk all dissolved. The substance in solution is no longer chalk but chloride of lime, soluble in water, which has been formed by the chemical action of the hydrochloric acid on the chalk.

Experiment 21.—Show that barium sulphate is insoluble in not only water, but in dilute and strong acids, such as hydrochloric and nitric.

(To be continued.)

ANDREWS' CONCENTRIC WIRING.

Messrs. J. D. F. Andrews and Co. have recently completed an installation at the Tyne Theatre, Newcastle-on-Tyne, for Sir Augustus Harris, the wiring being done on their concentric wire system. Our readers have long been acquainted with this system, and visitors to the Palace Exhibition will be able to fully examine the system for themselves.

In the Tyne Theatre installation the concentric principle is adhered to throughout, extending to the switches, fuses, fittings, etc., and in these, as in the wiring, we note the close attention which has been given to mechanical as well as electrical perfection. Incandescent lamps are used, and include six 200 c.p., 12 50 c.p., and about 180 8-c.p. lamps, all of which are on the stage. The former supersede the limelight for the floats, and, from facility of control and absence of hissing, are a decided improvement. The remaining lamps are used to illuminate festoons, statuary, etc., and the artistic manner in which they are arranged has a most pleasing effect.

The current is conveyed from the leads by means of Andrews' patent concentric flexibles. The fact of all fittings having to be connected and disconnected in a few minutes, owing to changing of scenes, and the consequent rough usage to which they are subject, is conclusive proof of their adaptability and mechanical perfection. The ease of manipulation of this system is obvious when we state that the electric lighting used in the garden scene of the present pantomime comprises nearly 200 lamps; and at the close of the scene the whole of these, as also the flexibles, are disconnected and stored away by two men in the short space of three minutes. At some points in the pantomime all the lamps have to be switched on and off. The current is derived from the mains of the Newcastle and District Electric Supply Company, of which Mr. W. O. Hunter is the manager.

The installation, which from its substantial and finished nature reflects credit on all concerned, has been carried out by Messrs. J. D. F. Andrews and Co.

Electric Lighting at the Tyne Theatre—Andrews' Concentric Wiring.

EDISON AND THOMSON-HOUSTON.

THE PROPOSED AMALGAMATION.

Thomas A. Edison, the "Wizard," the king of practical electricians, has been "done." The hands of Wall-street manipulators are seen everywhere in the act of his undoing.

The calm, clear-headed, big-hearted inventor relied on friends and business associates. The former were speculators; the latter have largely proved incompetent. The result of the intellectual giant's dependence will be the amalgamation of the Edison General Electric and the Thomson-Houston Companies. The reorganisation plan was practically agreed on several days ago. Henry Villard arranged it. Drexel, Morgan, and Co., the bankers who have succeeded in obtaining control of the majority of the stock of the Edison General Electric Company, were and are the powers behind the throne.

The coalition as arranged wipes out the Edison influence and transfers the goodwill of a business capitalised at 15,000,000dols. to the Thomson-Houston Company. The brainiest inventor of the age is asked to play "second fiddle" to Elihu Thomson, the practical man of the absorbing company. The scheme was planned by Mr. Villard and carried out before Mr. Edison realised what

was being done. He imagined that the immense financial interests he had brought into the General Company were being properly taken care of by the men he trusted. He never expected to be in a position where he would have to submit to the dictation of Wall-street manipulators.

When the details of the amalgamation plan were presented to him he frowned. It did not take him long to realise that he was in a sad minority, and that those who were engineering the scheme were in virtual control of a business that he had spent 15 years in building up. He was practically driven out of the General Company. Here is the way the situation presented itself to him:

"When the General Edison Electric Company was formed in the latter part of 1889, the Edison Electric Light Company, the Bergmann Company on Avenue B, the Edison Machine Works at Schenectady, N.Y., the Edison Lamp Company at Harrison, N.J., and the Sprague Electric Railway and Motor Company were the elements of the organisation. I owned a controlling interest in the Light Company and the majority of the stock in the Bergmann Company, the Edison Machine Works, and the Edison Lamp Co.

"I don't know what those interests were worth, but I do know that the companies that now represent 15,000,000dols. in capital under the title of the General Electric Company were practically controlled by me. Now, there is not, under the old separate organisations, even a suspicion of controlling power in my name."

Samuel J. Insull is the second vice-president and general manager of the General Company. He has been associated with Mr. Edison for a number of years. He was Edison's agent in London, and was invited to assume a responsible position in this country.

The *Morning Advertiser* learned on most reliable authority yesterday that a secret meeting was held between Messrs. Villard, Edison, and Insull a few days ago. Mr. Edison protested against the amalgamation, and Insull attempted to back up his chief. Villard turned on Insull, and said: "If it had not been for your gross mismanagement of the affairs of this great concern it would not have been necessary to enter into any such coalition as has been promulgated and is likely to be consummated by the stockholders at the meeting in May."

It is safe to say that Mr. Edison does not know exactly where he stands in the new deal. It was reported in Wall-street yesterday that the absorbing corporation would throw him out of the directory as soon as the amalgamation was completed. There is no truth in the rumour. It is well known that the Thomson-Houston people and their Wall-street friends are only too anxious to utilise Mr. Edison's brains.

The one question now is, Will the Wizard remain on the board of a concern that he knows is managed and controlled by rival inventors? A friend said yesterday, "It isn't a case of Edison being ousted from the board of directors; it is ten chances to one that the manipulators will not be able to keep him with them."

Samuel J. Insull will probably be deposed from the executive board and the general management. E. A. Coffin, of the Thomson-Houston Company will, it is said, take his place, and Mr. H. McK. Twombley will be the new president. Mr. Villard's work is done. His personal and pecuniary ambition is thoroughly satisfied.

The salary of 50,000dols. that attaches to the office of president he cares nothing for, as he declared some days ago to a *Morning Advertiser* representative. "The duties of the office are too exacting for the small compensation."

Mr. Edison's friends declare that he has been taken in by Wall-street "promoters."—*New York Herald.*

OIL AS AN INSULATOR.*

BY PROF. D. E. HUGHES, F.R.S., PAST-PRESIDENT.

At our last meeting Mr. Preece kindly gave me credit for being the first to propose the use of oil as an insulator for wires conveying an electric current; and in accordance with a suggestion on his part, I should like to state upon what grounds I can fairly be considered to be the first to urge upon the electrical world the use of hydrocarbon oils, such as petroleum and rosin oil, for this purpose.

In 1858 universal regret was felt on the failure of the insulation of the first Atlantic cable. From the first successful laying of this cable the insulation gradually became worse, until in a few days all signals failed. The cause of this was supposed to be due to minute flaws in the guttapercha during its manufacture, which became worse by submersion, or that lightning, or the intense currents then used for the Whitehouse induction coil, punctured the cable at several points.

It appeared to me (from some old experiments of mine) that what we needed was some form of insulation that possessed self-restoring powers, so that, if punctured by lightning, or our ordinary working currents, the puncture should be closed by some simpler process than having to take up a portion of the cable. I thought that Nature showed us the way in which *she* restores punctures and mechanical injuries to all living objects. This is done by a flow of liquid sap to plants, or blood in animals; for if we make an incision in the bark of a tree, the sap flows out and hardens in contact with air; if we cut our fingers, blood flows out and heals the wound. Therefore, I thought that if I could enclose in a cable an insulating self-restoring medium, the cable would not become dead at the first, or even after innumerable punctures. To carry out this object it seemed to me that a thick insulating oil, enclosed between the wire and its outer skin, would perfectly fulfil the conditions required.

Faraday had shown some years previously that oil of turpentine had a high insulating property, and this gave me great hopes that I should find, by experimenting with numerous samples of oil, the kind and quality desired for my purpose. Therefore I at once commenced a long series of experiments in order to find the best kind of oil and the most suitable form of cable to carry out this idea. Knowing that I could not fairly test these oils, or a short length of cable, by our ordinary voltaic currents, I had recourse to the very high potential currents given by the ordinary frictional static electric machine. The method used was this: I charged a battery of Leyden jars to a known degree, which was indicated upon the Leyden jars by a Peltier electrometer; these jars, when charged, were put into communication with the short piece of the cable to be tested, the outside of which was coated with tinfoil, or placed in water connected with earth, and exterior of the Leyden jars. By this means, if the insulation of the few inches of cable was bad, the Leyden jars would instantly be discharged through the defective insulation; but if the insulation was comparatively perfect, the time of discharge of the electrometer was a correct measure of its insulating properties. Of course this method required that the Leyden jars should be perfectly insulated and hold their full charge for at least one hour when not discharging through a defective cable.

On making preliminary experiments on several samples of guttaperch and indiarubber-coated wires, I found a marked difference in each variety; but as these differences were of a constant character for each sample, it was easy to tell which of these had the highest insulating property. These experiments showed me that if I wished to arrive at the true value of an insulating oil I must make the experiments by a method by which the result should be entirely free from any interior or exterior coating. For this I took two small flat circular discs, 1in. in diameter, which could be immersed in oil, and by an insulated adjustable screw I could compare the striking distance of these discs in air, compared with the same when immersed in oil, and could also observe the time required for a complete discharge of the Leyden jars through this medium.

On testing numerous samples of different oils, I found not only a great difference in the species of oil, but also a great difference in different samples of the same oil, consequently a table giving the results on different oils might be misleading, as a sample of superior quality of a certain oil (although inferior in many other samples) might give higher results than a badly selected sample of a really superior oil. The only difficulty as regards rosin oil is one of manufacture, or, rather, of finding, and teaching the makers, the quality of oil best suited for the purpose; for I found, on obtaining samples of this oil from different makers, that a great difference existed as regards their insulating properties, ranging from worse than castor oil up to a degree superior to guttapercha; and this is true of most oils; consequently, before using any oil, its quality as an insulator should be thoroughly known by constant electrical tests.

In selecting oil of high insulating quality, we must also have regard to the purpose for which it is to be used. Thus, as a self-restoring medium having very quick action, for condensers, transformers, or coils so closely wound as to be difficult for a thick oil to penetrate, a thin rosin oil, such as rosin spirit, might be best; but for cables and underground wires I found thick pure rosin oil best, because it was not only superior as an insulator, but it would not escape too rapidly at any large puncture.

Experiments were also carried on at the same time to observe the effect of any given oil on thin sheets of guttapercha, indiarubber, etc. These were immersed in separate vases of different oils, they were weighed before and after prolonged immersion; the result being that some oils were found to be injurious to guttapercha, and almost all, with the exception of castor oil, were more or less destructive to indiarubber. I found, after numerous experiments, that pure rosin oil gave the highest insulation of all, for a spark that would pierce a given thickness of guttapercha would utterly fail to pierce the same thickness of rosin oil; whilst, if the guttapercha was pierced, its insulation was destroyed and could not be easily restored to its former condition; on the other hand, if by accident the rosin oil was pierced, it, by its own mobility, at once restored the insulation to its original state. Rosin oil, at the same time, had a preservative effect upon guttapercha, for the sheets immersed in this oil had become slightly increased in weight, showing that it had penetrated into the pores of the guttapercha; at the same time it was stiffer and tougher than before immersion. I will now show you an actual specimen of this fluid cable, cut off from a specimen one mile in length, made by the Gutta Percha Company 33 years since. You will observe that the guttapercha has absorbed during that time a large proportion of the oil, and that the guttapercha is now, after 33 years' exposure to the air, apparently as good an insulator as when first made.

Experiments were now made as to the value of rosin oil when employed as the sole insulator of an electric cable. For this purpose, a short length of copper wire, say, 1ft., was coated, first, by being wound by well-dried cotton or hemp, or, better still, by a string wound round in wide open spirals, in order that the oil should penetrate as freely everywhere as possible; this was afterwards drawn into a small lead tube filled with rosin oil: thus the string or fibrous covering on the wire was simply to keep the wire concentric, so as to prevent its touching any part of the exterior tube without some separation of oil or oil-saturated fibre. It will be seen that these tests were identical, both as to form and material, in their essential points, with those patented by Mr. David Brooks, of Philadelphia, some 15 years later; but as these are clearly described in my patent of January 11th, 1859, there can be no question of priority in this respect, though, no doubt,

* Paper read before the Institution of Electrical Engineers, March 10, 1892.

many improvements suggested by practical experience in the mode of laying and manufacture are original with Mr. Brooks. The insulation of this form of cable was not quite as high as solid guttapercha, due to the fibre not being as good an insulator as the enclosed oil, but its mechanical powers of self-restoration and durability seemed to me to more than counterbalance its slightly less insulating power, for even with guttapercha there are questions of strength and durability which ought never to be lost sight of in favour of a temporary high insulation; and I think that when the value of fluid insulation is more thoroughly known, especially for currents of high potential, it will be more generally used than at present, particularly as there are now no valid patent rights to interfere. I again repeated these experiments, using a thinly-covered guttapercha wire for the inner conductor, drawn into a guttapercha tube full of rosin oil. This gave me very high insulation—so much so, that I tried a bare copper wire in the guttapercha tube alone, without any rosin oil; this, to my surprise, gave a far higher insulation than the best guttapercha-covered wires as supplied to me by the Gutta Percha Company. This surprised me very much, as the tubes, which I bought at an ordinary retail shop, were known to be of an inferior quality of guttapercha. I found afterwards that this difference was due to the tubes having been long made and kept in stock; they had gradually dried, and were free from combined moisture absorbed during their manufacture. I proved this by taking some newly-manufactured guttapercha, and heating it gradually for a length of time sufficient to drive off its moisture; this, when modelled on a wire, so as to form a cable, gave precisely the same degree of high insulation as the old tubes that I had purchased elsewhere. I do not believe that the mechanical quality of the guttapercha was improved by this operation; most likely it would have soon become brittle, for humidity, or an essential oil, seems necessary to its life and mechanical qualities. I told Mr. Chartterton and Mr. Willoughby Smith, of the Gutta Percha Company, of these results, and urged upon them the necessity of well drying the guttapercha and of manufacturing their cables, if possible, without constantly macerating it in water. I am not aware that my remarks had any effect, but this I remember, that in a few weeks after they gave me a sample, which they called "special guttapercha," which certainly had as good insulating qualities as my dried guttapercha.

As I have already said, my main object being to produce a self-restoring insulation for cables and underground wires, I found that a thin fluid, such as rosin spirit or petroleum, might be objectionable, as at the point of fracture or puncture the fluid might escape with so great a rapidity as to be somewhat costly in its maintenance; but by employing a thick, heavy, insulating oil, whose rate of flow would be small, this would displace any water in the puncture, provided that there was a slight head-pressure given to the oil at a reservoir at certain landing stations, then it would answer all practicable purposes. For this I preferred rosin oil, which is already a thick, viscid oil, and can be made more so by the addition of solid rosin dissolved in it, or by the addition of palm oil residue, which has a remarkable property of thickening resin oil. In order to satisfy those who might object to even a very small leakage of oil at the puncture, I made several compounds of rosin oil, mentioned in my patent, that should harden when in contact with water, and thus prevent any waste of oil at the fault or puncture. This static charge which I used was of high potential; the sparking distance in air, of the charge used, was about 1in., and it showed the remarkable insulation of rosin oil when $\frac{1}{64}$in. separation would effectually prevent such a spark passing through it. After having found this high insulating property of rosin oil, I coated all my Leyden jars and all parts where I desired high insulation with it, and by this means I was enabled to retain a full charge of the Leyden jars for several hours, in an atmosphere full of humidity. They have lately proved the value of oil insulation in Frankfort by the use of oil in transformers of 20,000 volts, and I am convinced that in all cases where we need a high insulation, together with the power of self-restoration, it can only be found in fluid insulators. It is useful in every case where it can be applied; it is far cheaper than guttapercha, and I have no doubt that it will soon be used for insulation in condensers as well as transformers. Mr. Nikola Tesla, in his late charming lecture, spoke highly of the use of oil in his transformers, saying that it not only gave a perfect insulation, but had the power of restoring the insulation whenever pierced or punctured, as he believed his coils were at least several times every day. I remarked during these experiments that, no matter how high the potential, the amount of leakage was equal in time, either with a high or low charge of the Leyden jars—that is to say, when the Leyden jars were discharging at a slow rate through a good insulator, the time of falling of the electrometer through any given number of degrees was very equal throughout its whole range from 200,000 to 1,000 volts.

Being desirous of repeating this evening some of my old experiments, I applied to Mr. W. H. Preece for some of the best samples of guttapercha-covered wires as used by the Post Office, and which he has most willingly sent me. I also applied to Mr. James Wimshurst, the inventor of his remarkable static electric machine, who at once most kindly consented to lend the machine, and also design an arrangement by means of which we could show to those at a distance the different distances of the sparking through oil compared with air. On testing this apparatus with oil, it seemed to show that the value of oil as an insulator increased both with the potential of the charge and also with the rapidity of alternations, for when the experiments were made by an impulsive rush so as to have the greatest number of oscillations per second—say 1,000,000—then even the poorest oil, such as castor oil, showed marked superiority over air or guttapercha. This confirms the *advantage of oil, and its* value in connection with the rapid alternating high-voltage currents used in our transformers of to-day. The experiments which we hope to repeat this evening have already shown us that a spark, or charge, from a Leyden jar which would easily pierce 4in. of air will not pierce $\frac{1}{16}$in. of rosin oil; proving that oil, when resisting an impulsive rush of a charge, has 79 times higher insulation than air. To obtain these results we used a large and most powerful Wimshurst machine; but this evening, for convenience sake, we shall use a smaller machine. We may not be able to obtain quite as high comparative values, still we hope to obtain results showing oil to be 50 times better an insulator than air. With the largest machine we obtained the following remarkable effects. The apparatus for holding the oil was a glass vase, 4in. in diameter by 3in. deep. The lower portion of this vase had a copper plate connected with one portion of the circuit. A brass knob, $\frac{1}{2}$in. diameter, connected with the other portion of the circuit, could be raised or lowered in this vase in order to show the different striking distances when the vase contained air or oil. This gave the comparative results already mentioned; but, in addition, we noticed that when the knob was only covered three-quarters with oil, the spark rose from the upper portion to the upper portion of the vase, and then descended on the outside in order to reach the lower copper plate—a course of some 5in. through air, compared with $\frac{1}{16}$in. through oil. If now the current was increased, the current, or spark, became a continuous sheet flow all over the entire surface of the vase, resembling in appearance a waterfall, or exactly imitating the well-known Gassiot cascade. On again increasing the charge, in an attempt to pierce the oil, the spark pierced the glass vase, making a small hole of about $\frac{1}{32}$in. diameter, at a place $\frac{1}{2}$in. above the surface of the oil; thus the spark preferred to pierce the glass and travel several inches through air, rather than traverse a distance of $\frac{1}{16}$in. through oil. I will now show several forms of oil insulation as applicable for submarine or subterraneous wires, and the remarkable power of self-restoration when the insulation is temporarily destroyed by a puncture or cut across so as to lay the wire bare for an instant.

It will be seen in the experiments following this paper that I have arranged a battery so that one pole is connected through a sensitive galvanometer to a metal tank containing salt water, the return circuit being completed through the salt water and wire to be tested to the other pole. If we take any sample of guttapercha-covered wire and place it in the water, the insulation seems perfect and all that could be desired; but if we make a small incision with a knife, so as to leave a minute portion of the copper exposed, then, as we already know, on placing this in the tank, the water at once percolates through the cut to the wire, and its insulation is completely and permanently destroyed. If we try this same experiment with oil cable, such as a bare copper wire in a guttapercha tube containing oil, or, better still as a proof, a thinly-coated guttapercha wire, and this plunged into a small lead tube containing thick rosin oil, the whole having the same diameter as the guttapercha-covered wires, we find on testing this lead-covered oil cable that its insulation is as perfect as the guttapercha wires. If we now cut through the lead tube and the guttapercha wire once or several times, so as to lay the wire bare, the insulation for an instant is destroyed, but in less than a second the oil percolates through the wound or cut, and its insulation is instantly restored to its previous high value. I believe that these experiments sufficiently show the merits of a self-restoring insulating medium, such as rosin oil, for all purposes where a permanent insulation of wires conveying an electric current is desirable.

In conclusion, I will mention a few proofs of my claim to be the first to recognise the value of oil insulation for wires conveying an electric current, based upon some earlier experiments, but patented January 11, 1859, entitled "An Improved Mode of Insulating Electrical Conducting Wires," which describes and claims most of that which I have already related. I will read a few sentences, in order to prove this fact. After showing how the oil may be applied to submarine cables, and in order to claim its application to underground wires, the specification says (page 3, line 10): "With some trifling modifications, the invention may be also applied for insulating electrical conducting wires employed on land or underground." As regards the materials used, it says (p. 4, line 23): "I propose and prefer to use rosin oil, rendered sufficiently thick or viscid for the purpose by the addition of rosin or the solid residuum obtained from the distillation of palm oil." In order to show that the interior wire may be covered with a fibrous material instead of guttapercha, it says (p. 4, line 34): "Instead of bringing the soft or semi-fluid restorative medium in direct contact with the enclosed wires, I sometimes first coat the wires with a non-conducting material, such as guttapercha or indiarubber, and if preferred, the wire may be previously covered with some fibrous material." My invention being as well adapted for numerous wires in an underground cable as in a single-wire cable, it says (p. 5, line 6: "And the invention is as applicable when two or more electrical conductors are placed in one common tube or outer covering as when only one conductor is employed." If the patent is hurriedly read, it would seem as if I only intended to use the oil in connection with guttapercha cables; but I foresaw the use of other outer covering, such as lead or iron tubes, for it says (p. 4, line 37): "The insulated electrical conductor thus coated or covered is then placed in a guttapercha or other tube." This phrase "other tube" referred to my experiments with an outer tube of lead or other metal; and I again employ the same phrase at page 5, line 13, where it says that the wires surrounded by the rosin oil "may be placed in the guttapercha or other outer covering." A paper on this subject was read before the Society of Arts and published in their *Journal* April 15, 1859, in which I demonstrated by practical experiments the restorative powers of my fluid insulation.

Sir William Fothergill Cooke, the chairman, in reply, spoke in praise of the results, and said he "also thought the invention would be very valuable as applied to the street wires of electric telegraphs, and these afforded more facilities for testing its value." So it cannot be said that its applicability to underground wires was not foreseen at that date. From 1858 to 1860 I tried by every means to get the various land and submarine electric telegraph companies to try this system, but in vain. I thus lost two years of valuable time, and then went to France in connection with my printing telegraph instrument, to which I devoted my whole time for many succeeding years, thus practically abandoning my self-restoring fluid insulation to the public. The cause of its failure to be used then was due to the fact that the invention was made before its time, or that the need of its use was not then as great as at the present time. I am glad to say that now, thanks to electric light and power, the use of a self-restoring oil insulation is fast coming into actual practice under the names and patents of numerous succeeding inventors; so I sincerely thank Mr. Preece for citing my early work, and thus giving me this opportunity of claiming as priority the work that I had done before and patented in 1859.

My best thanks are due to Mr. Preece for the samples of gutta-percha, wires, galvanometer, etc.; to Mr. James Wimshurst for the loan of his static electric machine, and for his great assistance in preparing some of our experiments on high-tension currents; also to Messrs. Grindley and Co., of Upper North-street, Poplar, for having supplied me with numerous samples of their best oil, from which I have selected the oil that I have used this evening.

ELECTRICAL TRACTION AND ITS FINANCIAL ASPECT.*

BY STEPHEN SELLON.

Considerable difficulty has been experienced in obtaining reliable statistics in connection with electrical traction as regards its alleged economy over other motive power. The author has therefore devoted considerable attention to this subject, and has, through his connection with electrical companies, been able to collect information which may be considered reliable. In claiming certain advantages for one system over another, especially as regards initial cost and working expenditure, the author has purposely adopted a somewhat dogmatic tone as an incentive to promote criticism and useful discussion, and for this purpose, especially as regards the commercial question, is this paper suggested as a means of ventilating this most interesting subject.

The well-known systems of electrical traction before the public are the following:

1. Accumulators, consisting of the E.P.S. and the Julien types.
2. Overhead, consisting of the Thomson-Houston, Edison, Sprague, Short, Rae, United Electric Traction Company, Daft, and Van Depoele types.
3. Conduit, consisting of the Lineff, Gordon, and Wynne types for closed conduits; and the Waller-Manville and Blackpool types for open conduits.

For the purpose of convenience the author will consider each system in the above order.

Accumulator System.

This system of traction, which involves carrying the necessary power stored up in the cars by means of storage batteries, has been attempted to a small extent in America, Brussels, London, and Birmingham. Having no exposed conductors, the system is favourably looked upon by local authorities and tramway companies. As a mechanical means of traction it is workable and very fairly satisfactory. In a commercial sense it has proved a failure. Apart from its features of rapid depreciation and great weight, the accumulator system of electric traction is preferable to any other. Its chief defects are (1) a great increase to the tare weight of the car, varying from five to six tons—most horse tramways are not built strong enough to receive this additional load; (2) the rapid deterioration of the plates (estimated at nearly 200 per cent.). and requiring frequent renewals. No reliable figures have been given as to the operative expenses of the accumulator system, but its abandonment at Brussels and in America is suggestive of commercial failure.

On the Birmingham Central Tramway, it is stated, by a report of the directors issued August 11th, 1891, to be a success, but no item is given for depreciation, as compared with other methods of traction. The following table gives the working expenses per car mile for the four different systems of traction in use by this company:

Working cost	per car mile	with	steam	10·99d.
Working	,,	,,	horses	9·79d.
Working	,,	,,	cable	6·33d.
Working	,,	,,	electricity	9·90d.

It is worthy of note that this tramway company, in an extension Bill last session, fought the telephone clauses most vigorously, and on being defeated they abandoned their Bill. This action would point to a disbelief in self-contained cars, to which the telephone clauses do not apply, and that the directors realised the necessity of seeking powers for the establishment of a different system in the future.

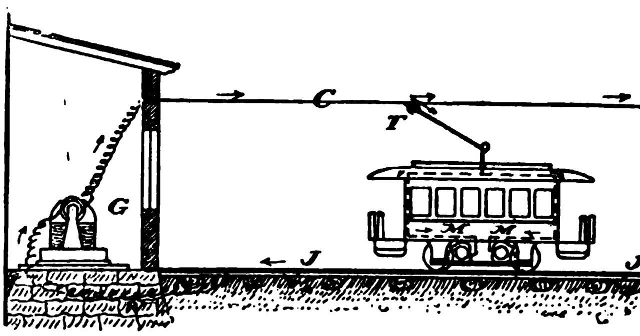
The National Telephone Company over the whole of their system use the earth as a medium for their return circuit. The current used by them is so exceedingly minute that any larger current disseminated through the earth in the same neighbourhood creates such a disturbance by induction as to render the telephones practically useless.

For this reason the telephone company has, in late years, made a most vigorous opposition in Parliament to any tramway company asking for electrical powers, unless they accepted certain telephone clauses in their Bill; these clauses practically allocate the use of the earth for telephone circuits alone. In view, however, of the opinions expressed by Mr. Preece, the electrical engineer to the Post Office, and other authorities, the author was the first to refuse to accept the introduction of these clauses in a Bill he had the conduct of, and he succeeded in convincing a committee of each House of Parliament that the earth should be a common property, and each company must protect themselves from external electrical influences.

In consequence of an alleged disturbance to the Leeds telephones by the working of the Roundhay Park electric tramway, the Act for which contains no telephone clauses, an action for damages has commenced between the National Telephone Company and the Roundhay Tramways; the result will be looked forward to with interest by the tramway and electrical world.

The Overhead System.

This system, which is to be seen now in operation on the Roundhay Park section of the Leeds Corporation tramways, is the first introduction of its kind into England, and the author was one of the parties concerned in obtaining the concession.* The line is $5\frac{1}{2}$ miles in length, and has now been working for more than three months. The fact that the Leeds Corporation have lately granted an extension of the system speaks well for its popularity. The diagram shows the method adopted for supporting the trolley wire or conductor. Six cars, each carrying two 15-h.p. motors, serve the line, and the generating plant consists of a single high-speed engine belted to two 80-h.p. dynamos; the whole of the electrical work was supplied by the Thomson-Houston Company, of America.



The marvellous development of this system in that country during the last six years is shown by the following table:

In 1885	there were	3	roads equipped with	13	motor cars
,, 1886	,,	5	,, ,,	39	,,
,, 1887	,,	7	,, ,,	81	,,
,, 1888	,,	32	,, ,,	265	,,
,, 1889	,,	104	,, ,,	965	,,
,, 1890	,,	126	,, ,,	2,000	,,
,, 1891	,,	405	,, ,,	5,099	,,
,, 1892	,,	436	,, ,,	5,851	,,

The following are the principal firms supplying installations on this system and their mileage extent:

	No. of roads.	Mileage.	Motor cars.
Thomson-Houston	200	2,113	3,040
Edison (Sprague)	167	987	2,061
Short	26	180	301
Rae	36	157	278
United Electrical Traction Company (Daft)	20	62	116
Van Depoele	7	33	55
Total	436	3,532	5,851

Beyond mechanical details the principle is substantially the same with each firm. The Thomson-Houston has the largest business, which the author thinks is owing to an elaborate system of testing and inspection before work is allowed to leave their factories, and to general excellence in detail work which has prevented the unfortunate failures in motors, etc., which were so frequent in the earlier days of electric traction. They cannot claim, however, either cheapness or superiority of manufacture.

The objection to the general introduction of the overhead system in England is the necessity for an overhead conductor and the erection of standards in the streets. This is, however, in some measure an insular prejudice soon to be removed, and though it is doubtful whether the overhead system can be introduced in the centre of large towns, it will, without doubt, be largely used in the suburban districts. Within the last few months such towns as Walsall, Leeds, and Bradford have assented to its adoption in their outskirts. It is without exception the cheapest in initial cost, but the working expenses, though less than those of accumulators, are not necessarily less than the working expenses on the

* A paper read before the Society of Engineers on Monday, March 7.

* This tramway was fully described and illustrated in our issue of November 6, 1891.

conduit system of electrical traction. Statistics received from America show a large increase in revenue and a decrease in working expenses of tramways after its adoption, and in dealing with these figures it is necessary to remember that as the Railway Commissioners in America have the power to reduce tramway fares on publication of good dividends, it is against the policy of the various companies to publish returns showing large profits.

The following show the working expenses of some of the best known electrical tramways as against horse, steam, or cable traction. In comparing English and American statistics it is necessary to remember that the percentage of working expenses in America is larger than that in England, owing to labour being much dearer and also the extra price of coal where mechanical power is used. According to the reports issued by the Railway Commissioners in America for the year ending June 30th, 1890, the average working expense of horse tramways is 79 per cent. of the gross earnings. The average working expense of horse tramways in England, according to the Board of Trade returns, is 77 per cent. of the gross earnings.

The largest street railway system in the world is the West End, Boston, Mass. Electric traction is fast supplanting horse traction on this line. In June last the mileage proportion between horse cars and electric cars stood at 3 to 1. The operating expense by horse traction was 66·70 per cent. of the gross earnings, while that of electric traction was 47·70. The electric cars are operated on the same lines with horse cars, and at present the former run about 25·15 per cent. of the entire mileage. The popularity of the system is shown by the fact that the electric cars earned £5,555 more than their proportion of the mileage. If the system was extended over the whole line the increased net earnings on these figures would have been over 52 per cent. of the present earnings. The increase of traffic due to the substitution of electric traction for horse traction on this tramway is 44·1 per cent.

In April and May the cost of operating (motive power) per horse car was		....	5·38d.	per car mile.
In June	ditto	ditto	5·14d.	,,
In April the cost of operating (motive power) per electric car was		....	3·79d.	,,
In June	ditto	ditto	3·64d.	,,
In July	ditto	ditto	3·47d.	,,

Taking the months of April, May, June, and July, the electric cars increased their earnings per mile run from 16·86d. in April to 18·97d. in July. For the same months the horse cars increased their earnings per mile run from 15·73d. in April to 18 11d in July.

It cost in April,	per mile run,	horse cars	....	12·65d.
,, ,,	,,	electric cars..	.....	10·77d.
,, July	,,	horse cars	....	12·06d.
,, ,,	,,	electric cars....... .		10·14d.

On examining the returns of this tramway it appears that the net earnings per car mile of the electric system over the horse system is 4·98d. There are two reasons for this. First, economy of working, and second, increase of traffic due to what may be called "public satisfaction." If this amount is divided into two parts, one part representing the former and the balance the latter, we find that the operating expenses of the horse line exceed those of the electric by 1·92d. per car mile; subtracting the difference of earnings from the difference of expenses the result is 3·06d. per car mile, which amount represents the net profit of electric lines over horse lines due to "public satisfaction."

In another example it is shown that a certain tramway six miles long worked by horses up to September 30th, 1889, making an annual mileage of 87,708 car miles, earned, with five cars, £1,500 net. The following year on the same tramway worked by electric traction with the same number of cars, 117,450 miles were run, and the earning capacity of the road was increased 37½ per cent. over that of horse traction, while the operating expenses per car mile were reduced from 8·4d. to 6·9d.; in other words, the net earning capacity of the road was increased £1,740 per annum at an increase of cost of £350.

In another case eight horse cars worked a road at 63 per cent. of the gross receipts. On eight electric cars replacing the horse cars the working expenses were reduced to 53 per cent. The Minneapolis street railway, having 120 miles entirely equipped and worked by the overhead system, has just issued its first report. It shows gross earnings for July £22,133, operative expenses £10,819, or 49 per cent. of the gross earnings. The Louisville Railway Company, in their report for the year ending 1890, put the cost of working by horses at 68·36 per cent. of the gross earnings, and the cost of electric traction at 51 56 per cent.

The Denver Electric Tramway Company state the cost of operating for seven months for the year ending 1890 at 55 per cent. of the gross receipts. These tramways are some of the most important in North America. In an official census published in April by the United States Government statistics of the working of 30 horse, 10 electric, and 10 cable tramways were given. The results were as follows: Horse per car mile 8d., cable per car mile 7d., electric per car mile 6·30. It should be noticed that operating expenses include general expenses, track and car expenses, and motive power, including drivers and conductors.

THE CONDUIT SYSTEM.

Where the overhead system is objected to, tramway companies must turn their attention to the conduit system, of which there are two types—viz., the closed conduit and the open conduit. Of the former we know little, and it has never been commercially applied. The Lineff system is a closed-conduit type, of which a few yards of experimental track has been laid down in the Hammersmith depôt of the West Metropolitan Tramways. In this system an exposed rail is bolted to a tee-iron, which is buried in the track in asphalte; underneath the flanges of the rail and tee-iron is left a small chamber containing a copper conductor laid on glazed tiles, and on the top of this a strip of galvanised iron; the surface rail is in electric and magnetic contact with an electromagnet carried under the car. The electromagnet, while passing over the short lengths of insulated surface rail, attracts upward the loose strip of galvanised iron, and thus a contact is made with the copper conductor, forming an electrical connection between the copper and a few lengths of the insulated rail under the car; the current then passes through the body of the electromagnet and thence to the motor. This is really an old abandoned system under a new name. Since this was written the author is informed that three miles of this system is to be immediately laid down on the West Metropolitan Tramways.

The Wynne and the Gordon systems would appear at the present time to be still in the experimental stage.

Looking at the closed-conduit system from a commercial as well as from a technical point of view, it is as at present before us open to three grave objections: firstly, the necessity of putting short lengths of surface rail temporarily into circuit by means of some electromagnet device appears too complicated to be reliable in working; secondly, the practical impossibility of making such a system thoroughly insulated in a street subject to heavy traffic; and thirdly, supposing these two difficulties to be overcome, the impossibility of ensuring a proper contact when the road is covered with water, dirt, or snow, and the impracticability of laying short lengths of rails with sufficient rigidity in a street where there is heavy traffic.

Until further practical demonstrations of its working are forthcoming, it is useless discussing it any further in this paper.

In the open-conduit system the electrical power is taken from a conductor placed in a conduit built either under one rail or in the centre of the track. Apart from any difference of capital cost it is superior to the cable, especially in working, as the cars can travel either way by reversing, and at a variable speed, at the will of the driver, which is impossible in the cable system.

The only example of the open-conduit system in England is the Blackpool tramway, built by Mr. Holroyd Smith. This line has been worked commercially since 1885 with considerable success. Last year Sir George Bruce and the author went carefully into the working expenses of this tramway on figures supplied to them by Mr. Woodley Smith, the accountant and auditor for this tramway and the London tramways. This line was found to be working at an average percentage of 35 per cent. of the gross receipts, and was an improving property, as the following dividends will show: In 1888 it paid 4 per cent.; in 1889, 7 per cent.; in 1890, 7½ per cent. As a first attempt, all credit is due to Mr. Holroyd Smith for the way in which this installation was put down, but there are many features in it which do not warrant it being called *the* conduit system of the future.

Built along the public promenade, it has but few of the difficulties to contend with in obtaining perfect insulation which would be met were it laid in a public street, subject to the dirt and mud inseparable from ordinary street traffic. The continual action of the spray in winter from the sea produces leakage, showing that the system is deficient in perfect electrical construction. The conductors are laid on what Mr. Holroyd Smith calls porcelain insulators fixed in creosoted wood; when all this is wet imperfect insulation must ensue, and much more so when covered with wet mud. This being so under the very favourable conditions at Blackpool, it is probable that the leakage would be so great, were such a line laid in an ordinary street, as to practically prevent working. The conduit construction on this line is designed too weak to support the ordinary vehicular traffic of public streets.

Owing to the many faults both in mechanical and electrical application of electricity to the conduit system at Blackpool, the Waller-Manville system has been produced. It is somewhat misleading that this arrangement of enclosing conductors and contact wires in conduits should be termed a system, inasmuch as it involves no new method of distribution, but merely consists of a number of well worked out mechanical details to render the application of the conduit, as exemplified at Blackpool, practicable under the ordinary requirements of tramway service.

In the Waller-Manville type, the experience of a practical tramway engineer has combined with the experience of a practical electrician to produce a form of conduit traction superior to any other. The insulation is practically perfect. The conductor being a flexible cable it requires fewer supports than in the case of a rigid conductor, and these supports are situated in chambers covered with hatches similar to though smaller than those in use on cable tramways. The conductor, being flexible, can be taken out or replaced through the slot without interfering with the conduit, which is impossible in the Blackpool system. With a rigid conductor, as at Blackpool, frequent supports are necessary, so that it is impossible to provide means of access, and by reason of the infrequency of the supports to the Waller-Manville system, large insulators can be used, owing to the available space in the hatchways, whereas, in the rigid conductors the supports are necessary in the conduit, and liable to become covered with mud, and, as before pointed out, they cannot be got at for the purpose of cleaning or renewal. Every precaution is taken against the introduction of dirt. The whole has been designed so as to be constructed at a cost that will compare favourably with any conduit system.

THE COMMERCIAL QUESTION.

Being entirely governed by capital cost, working expenditure, and depreciation, a hypothetical case of three miles of tramway is taken, and as it is very difficult to apply the cable system to a single line with passing places, a double track example is taken,

and one gradient of 1 in 20, 880 yards long in the centre of the system, is assumed. It is proposed to furnish the same with an equipment sufficient for a 10 minutes' service by horse, cable, or electricity, including the overhead and conduit systems. The capital cost and average working expenditure of each system has been carefully compiled from such detailed information as has been obtainable, and is verified by the author's own personal knowledge and experience.

In the estimates of capital cost any allowance for depôt buildings and land has been excluded, as, although the figures would show somewhat in favour of mechanical systems, they might be taken for this purpose as costing about the same in each case; and as the value of land varies in different localities and the cost of a depôt is a very variable item in accordance with the class of work which may be put into it, it is better on the whole to exclude this item. The capital cost expended on the construction and equipment of a horse line may reasonably be taken at £25,800, of which £21,000 represents the cost of the tramway and the balance the equipment.

In dealing with the mechanical systems it is assumed that the cost of the construction of a horse line should be added to the cost of converting the line and equipping it on the respective systems of mechanical traction, and it has not been thought fair to charge these systems with any portion of the cost of the horse equipment, because the equipment should represent its full original value if a proper sinking fund has been provided, and on this basis the capital cost of horse, cable, overhead, and conduit lines is estimated as follows:

Capital cost of horse line	£25,800	exclusive of depôt.
,, ,, overhead line	32,000	,, ,,
,, ,, conduit line	41,500	,, ,,
,, ,, cable line	48,000	,, ,,

In regard to the working cost of these systems the figure put down (which in each case includes a reasonable allowance for maintenance and repairs) has been arrived at, as regards the horse line, from the large amount of information which is available on the subject. As regards cable traction, the last balance-sheet of the Birmingham Central Tramways Company's cable system has been taken, and the figures which they give have been adapted to the example given. It is necessary to point out that the efficiency of a cable tramway depends in an exceptional degree on the car mileage, which in Birmingham is very large. The figure arrived at in this case has been checked by reference to American statistics, and by other means, and it may be considered as a fairly accurate estimate. At any rate, it would not be safe to assume that a cable line of this size, and with the specified service, could be worked at a cheaper rate than that given later on. In the two electrical systems the actual details of the cost which would be involved has been very closely gone into. The estimates given are very sufficient, and there can be no reasonable doubt whatever that such a line could be worked at the price stated. There is no appreciable difference in the cost of working an overhead and a conduit system. It should also be stated that these estimates, besides including maintenance and repairs, as above stated, also include the cost of the car drivers, which is a very considerable amount, and is not infrequently omitted in estimates of cost of traction. The following are the figures, the rate per car mile being based on car mileage of 197,000 per annum:

	Per annum.		Per car mile.
Cost of working horse tramway	£5,750	equals	7·0d.
,, ,, cable ,,	5,750	,,	7·0d.
,, ,, overhead ,,	3,200	,,	3·90d.
,, ,, conduit ,,	3,200	,,	3·90d.

In order to compare the relative conditions of working with horse or with one of the mechanical systems referred to in the preceding estimates, it is assumed that in order to raise the extra capital required for each of the mechanical systems over and above the capital necessitated for a horse line that debentures must be issued at 5 per cent., so that the original capital for all the systems will be the same as for a horse line, and this capital has been taken at £35,000, being an extra sum of £9,200 to cover cost of depôts and working capital beyond the figure of £25,800 included in the preceding estimate. The amount of debentures to be issued would, therefore, be as follows:

Overhead line £6,200, equal at 5 per cent. to £310 per annum.
Conduit line £15,700, equal at 5 per cent. to £785 per annum.
Cable line £22,200, equal at 5 per cent. to £1,110 per annum.

The debenture interest must, therefore, be added to the working cost of each of the mechanical systems in order to compare them directly with a horse line. We therefore have the following figures of working cost:

	Ordinary working cost.		Debenture interest.		
Overhead line	£3,200	plus	£310	equals	£3,510
Conduit line	3,200	,,	785	,,	3,985
Horse line	5,750	—	—	—	5,750
Cable line	5,750	,,	1,110	,,	6,860

These preceding figures show that for a line of this description a cable tramway is more expensive to work than a horse line after making provision for the debenture capital involved by the cost of reconstruction. The following figures show the amount saved per annum by the overhead and conduit systems as compared with a horse tramway:

Overhead	£5,750	minus	£3,510	equals	£2,240
Conduit	5,750	,,	3,985	,,	1,765

and these amounts show an increased dividend available on the ordinary share capital, £35,000, upwards of 6 per cent. per annum in the case of the overhead line, and upwards of 5 per cent. per annum with a conduit line.

LEGAL INTELLIGENCE.

THE LANE FOX CASE.

The important action of Lane Fox *v.* Kensington and Knightsbridge Electric Lighting Company, Limited, has been progressing before Mr. Justice Smith in the High Court of Justice, Chancery Division, for 10 days. We intend to fully refer to the case upon its conclusion. Meanwhile, the following statement of the case will be of interest.

At the conclusion of Tuesday's proceedings, his Lordship said he would resume the hearing of the case on Monday next, at 10.30 a.m. Counsel for the defendants stated that they had three or four more witnesses to call, and it is not probable that the case will be finished before Wednesday afternoon, the 16th inst. We doubt if it will be finished then. The action is brought by Mr. St. George Lane Fox to restrain the defendants from continuing an alleged infringement of his patent, and for incidental relief. The plaintiff is the registered owner of letters patent No. 3,988, of 1878, granted to him for an invention for improvements in obtaining light by electricity, and in distributing and regulating the electric currents for the same, and in the means or apparatus employed therein. The infringement was alleged to have taken place by the use of secondary batteries as reservoirs of electricity in combination with a mode or system of distribution, substantially the same as that described in the specification, at the defendants' premises in or near Kensington High-street and Chapel-place, Brompton-road, Knightsbridge. The modes of distribution complained of were alleged to be (1) the use of the secondary batteries in combination with a number of lamps placed in multiple arc between two main leads; (2) the use of secondary batteries in combination with two or more systems of multiple arc distribution, in which one or more of the main leads are common to two or more of the said systems. The defences were (1) that the plaintiff was not the true and first inventor; (2) that at the date of the issuing of the writ the plaintiff was not the owner of the letters patent; (3) non-admission that the plaintiff was the registered owner; (4) want of utility; (5) invalidity of patent on several grounds, such as improper subject-matter for a patent, want of novelty, non-fulfilment of condition by filing a proper description of the invention within six months after the grant of the patent, differences between the provisional and complete specification, anticipations by prior patents and publications.

The Attorney General (Sir R. Webster) Mr. Moulton, Q.C., and Mr. J. C. Graham are for the plaintiff; and Sir Horace Davey, Q.C., Mr. Finlay, Q.C., and Mr. Roger Wallace for the defendants.

COMPANIES' MEETINGS.

LIVERPOOL ELECTRIC SUPPLY COMPANY, LIMITED.

The ninth annual ordinary meeting of this Company was held at Liverpool on Friday, 4th inst., Mr. A. H. Holmes, chairman, presiding.

The report, which was taken as read, stated that the amount of net profit available for dividend, including the balance brought forward from last year, was £7,866. 14s. 9d. Out of this sum they recommended a payment of a dividend of 4½ per cent. per annum, absorbing £6,580, adding £500 to reserve fund, and carrying forward the balance to next year's account. They considered the time had arrived when, in addition to writing off depreciation, a provision should be made for the renewal of mains and plant which might be necessary in the future, and they had therefore initiated a renewal fund, to the credit of which they had passed a sum of £1,500. The expenditure on capital account during the year (including a proportionate charge for general expenses) had been £17,122. The demand for electricity continued to increase, and the number of lamps connected with the Company's supply mains on December 31, 1891, was equivalent to 14,966 lamps of 16 c.p. each. During the year provisional orders had been granted to the Company by the Board of Trade for an additional area in Liverpool, including London-road, Prince's-road, and Prince's Park, and also for an area under the Toxteth Park local authority, including Sefton Park and the adjacent residential district. Both these provisional orders were for the full statutory term of 42 years. The Directors had obtained the consent of the Watch Committee, which had been confirmed by the City Council, to a provisional order under which the date for compulsory purchase, on the terms of the Electric Lighting Acts, of the Company's undertaking authorised by the provisional order of 1889, was postponed from 21 to 42 years; the Corporation to have the option of taking over the Company's supply business in the city of Liverpool as a going concern after December 31, 1897, at a price to be fixed by arbitration, as in the case of property taken under the Lands Clauses Consolidation Acts.

The **Chairman**, in moving the adoption of the report, announced that the business during the past year had been very materially increased, and that their prospects were very good. People were beginning to appreciate what a benefit to health and cleanliness the electric light was. The report showed that they had done a very much larger business, and that they were likely to do an increas-

ing business in the future. With the increased business they had made increased profits. The dividend of 4½ per cent. had been very fairly earned. With regard to the renewal fund, he thought the shareholders would see that it was a very wise action on the part of the Directors. The demands for their electricity had increased very much. On the 1st of January last year the number of lamps was 11,750; on the 1st of January of this year the number was 14,966; and at the present moment the number of lamps for which they had orders to supply was 16,900, which he thought was a very satisfactory state of affairs. In respect to the expenditure on capital account, it had been nearly all absorbed in extending their mains over the increased area. The extension was from Abercromby-square, up Mount-pleasant, along Bedford-street in the direction of the junction in Prince's-road up to St. Margaret's Church. Another extension would go up to University College, and also up London-road. In all these areas they had received a considerable number of promises from people who were anxious to use their light. The Directors had come to an arrangement with the Corporation by means of which the whole of their undertaking was placed on the basis of the 1891 order so far as the time went. They might consider that 42 years from now the whole undertaking was their own property, and could not be taken away from them except on the special terms mentioned in the report. In the event of the Corporation desiring to take the concern over in 1897 they would have to pay the Company such a price as would compensate them for the loss of their undertaking, and give them a fair return for the money that had been expended. He thought it was one of those happy arrangements by which all would be benefited. It would not only be a benefit to the Company, but to the Corporation and the city at large, and especially to the consumers, who would be able to get the electric light at a lower price than would have been possible had the arrangement not been carried out. He hoped that eventually, they might be able to induce the Corporation to get the work of making good the roads disturbed in laying down the mains done by contract, and also succeed in prevailing upon them to follow the examples of Manchester, Birmingham, and other larger and smaller places and have the electric light supplied to the Town Hall. He believed that they were behind Bootle in this matter. He thought it was scandalous that a great city like that, having such lovely rooms at the Town Hall, should persist in retaining the old-fashioned gas arrangement. He was pleased to say that the Electric Supply Company were on most excellent terms with the gas company.

The motion was seconded by **Mr. D. de Ybarrondo.**

Mr. J. Lister moved as amendment that the Company should pay the income tax on the dividend.

Mr. C. Birchall seconded the amendment, and hoped that there was a prospect of a considerable reduction in the expense of the lamps.

The **Chairman** replied that there was a balance on the right side sufficient to enable the Directors to do as had been proposed.

The motion as amended was then agreed to.

Mr. Goffey asked whether there was any truth in the assertion as to the 7 per cent. restriction?

The **Chairman**: It is not exactly that. There is, however, a great deal of truth in it. As soon as we reach 7 per cent. dividend, anything beyond that will have to be divided between the Company and the consumers. With regard to the cost of the lamps, I may say that when the patent expires, as it will do next year, instead of paying 4s. or 5s. per lamp, the price will be about 1s. 3d. for each lamp, and perhaps less than that.

The re-election of Messrs. A. H. Holme and D. de Ybarrondo as directors was proposed by **Sir David Radcliffe**, seconded by **Mr. Dansfield**, and carried.

A sum of 400 guineas was placed at the disposal of the Directors as remuneration for their services during the past year, free of income tax.

Mr. W. L. Jackson was re-elected auditor.

On the motion of the **Chairman**, seconded by **Sir David Radcliffe**, the meeting recorded its approval of the provisional order now being promoted by the Board of Trade, and also its approval of the amendments agreed upon between the Corporation and the Company.

A vote of thanks to the Chairman concluded the proceedings.

COMPANIES' REPORTS.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY.

Directors: Alfred Sohier Bolton, Esq., Sir Fredk. J. Bramwell, Bart., F.R.S., G. H. Hopkinson, Esq., Granville R. Ryder, Esq., R. W. Wallace, Esq.

Report by the Directors presented at the fifth ordinary general meeting, held at 1, Great George-street, Westminster, yesterday (Thursday) at 5 p.m.

The Directors beg to submit to the shareholders a statement of the accounts of the Company, together with a report of the position of the undertaking at the end of the year 1891. The mains, which extended for a length of 10 miles in the previous year, have been increased during the year 1891 to 12¼ miles. During the year the number of houses and shops connected with the system has increased from 291 on the 31st December, 1890, to 436 on the 31st December, 1891, while the number of lamps, calculated on the usual basis of 8 c.p., has increased from 25,535 to 38,408. The plant at the Company's stations has been worked at a greatly increased rate of efficiency especially during the last half-year, and further improvement in this respect is still being made. Provision has been made at Kensington Court for fixing a new boiler, and at Chapel-place three new engines have been added during the year to meet the rapid increase in the demand at this station. The funds required by the Company for extension during the past year have been raised by the issue of 4½ per cent. debentures, and it has not been found necessary to issue any of the second preference shares authorised at the last meeting. The dividend on the 6 per cent. preference shares was duly paid to June 30, 1891, and out of the balance standing to the credit of the net revenue for the year 1891, £3,810. 11s. 3d., the sum of £1,462. 10s. has been appropriated for the payment of the preference dividend to that date, leaving £2,348. 1s. 3d., out of which it is proposed to pay a dividend on the ordinary shares at the rate of 2 per cent. for the year, carrying forward £848. 1s. 3d. to the next account. In accordance with the articles of association Mr. A. S. Bolton and Sir Frederick J. Bramwell, Bart., F.R.S., retire from the directorship, and being eligible offer themselves for re-election. The auditors, Messrs. Lovelock, H. W. Whiffin, and Dickinson, offer themselves for re-election.

Dr. Balance-sheet, December 31, 1891.				£	s.	d.
Capital, 15,000 ordinary shares of £5 each				£75,000	0	0
,, 10,000 first preference shares of £5 each				50,000	0	0
,, 82 4½ per cent. mortgage debentures of £100 each	£8,200	0	0			
Less amount due	270	0	0			
				7,930	0	0
Sundry creditors on bills payable and open accounts				11,347	16	2
Renewal account, balance at credit thereof				1,713	5	0
Net revenue account				3,810	11	3
				£149,801	12	5

Cr.				£	s.	d.
Plant, buildings, mains, furniture and fittings, provisional order, and goodwill				134,890	11	10
Freehold and leasehold property	£5,713	3	11			
Less depreciation	189	16	2			
				5,523	7	9
Preliminary expenses and cost of debenture issue				750	3	6
Sundry debtors				5,353	18	1
Stock in trade and stores				905	0	8
Consols				549	3	10
Cash at bankers—Messrs. C. Hopkinson and Sons	£1,453	9	1			
,, ,, London and County Bank	348	19	6			
Cash in hand	26	18	2			
				1,829	6	9
				£149,801	12	5

Dr. Revenue Account, December 31, 1891.	£	s.	d.
Manufacturing electricity, coal, oil, water, waste, wages, and sundries	4,067	11	11
Repairs on leasehold property	60	17	4
Repairs to apparatus on consumers' premises	176	3	9
Incandescent lamps	143	7	8
Salaries	886	1	6
Miscellaneous expenses, including law charges, auditor, and bad debts	686	19	11
Rent, rates, and taxes	758	8	3
Insurance	72	19	10
Renewal account, in respect of buildings, mains, plant, batteries	1,850	0	0
Sinking fund	104	2	0
Balance	4,381	17	9
	£13,188	9	11

Cr.				£	s.	d.
Sale of electricity	£12,835	0	11			
Less rebates	568	4	1			
				12,266	16	10
Rent of meters				439	17	2
Repairs to apparatus on consumers' premises				162	13	7
Sale and maintenance of lamps				131	19	10
Rent receivable				185	0	0
Transfer fees				2	2	6
				£13,188	9	11

Dr. Net Revenue Account.	£	s.	d.
Dividends at the rate of 6 per cent. per annum on first preference shares, June 30th, 1891	1,301	11	8
Interest on debentures accrued due to date	133	8	0
,, temporary loans	38	1	0
Balance	3,810	11	3
	£5,283	11	11

Cr.				£	s.	d.
Balance from last account	£1,804	2	2			
Less first preference dividend to December, 1890	922	18	3			
				881	3	11
Balance brought from revenue account				4,381	17	9
Interest				20	10	3
				£5,283	11	11

Dr. Renewal Account.	£ s. d.
Maintenance of plant, buildings, mains, meters, instruments, etc.	1,535 9 1
Balance as per balance-sheet	1,713 5 0
	£3,248 14 1
Cr.	£ s. d.
Balance from last account	1,398 14 1
Amount brought from revenue account	1,850 0 0
	£3,248 14 1

NEW COMPANIES REGISTERED.

Eston Arc Lamp Syndicate, Limited.—Registered by H. W. Christmas, 42A, Bloomsbury-square, W.C., with a capital of £25,000 in £5 shares. Object: to carry into effect an agreement, made February 18, between T. P. C Crampton and A Essinger of the one part, and G. W. Yorston, on behalf this Company, of the other part, and generally to carry on business as electricians and electrical engineers in all its branches. The first subscribers are:

	Shares.
A. Essinger, 19, Clifton-hill, St. John's Wood	1
T. Sturgeon, Alexander-crescent, Ilkley, Yorkshire	1
J. A. White, 38, Holborn-viaduct, E C.	1
F. E. Pearl, 27, Ivanhoe-road, Denmark-park	1
M. J. Alexander, 68, Carlton-hill, N.W.	1
W. W. Westcott, 396, Camden-road, N.	1
E. J. de Buriatti, 38, Holborn-viaduct	1

There shall not be less than three nor more than six Directors. The first are W. W Westcott, G. North, J. A. White, and A. Essinger. Qualification, 20 shares. Remuneration, £2. 2s. for each Board attendance, with a further sum of £50 for each 10 per cent. paid as dividend.

Hobart Tramway Company, Limited.—Registered by Linklater, Hockwood, Addison, and Brown, 2, Bond-court, Walbrook, E C., with a capital of £105,000 in £1 shares. Object: to apply for and carry into effect any Act of Parliament (imperial or colonial), provisional order, concession, or contract, for the establishment, construction, maintenance, or working of tramways in Hobart and in any part of Tasmania or elsewhere, and, with a view thereto. to carry into effect an agreement, made December 18, 1891, between Messrs. Symes and Grant, as agents of the Hobart Tramway Company, Limited (of Hobart), of the one part, and F. J. Warner, on behalf of this Company, of the other part; to carry on the business of an electric light and power company, as shipowners, and to establish and maintain canals, railways, and tramways, as carriers of passengers and goods, to acquire patents, patent rights, etc., and to develop and work the same. The first subscribers are:

	Shares.
A. F. McLellor, 24, Bedford-road, Tottenham	1
R. D. Wilkinson, 2, Elmwood-road, North-park, Croydon	1
C. A. Miller, 6, Carlingford-road, N.W	1
A. D. Foggo, 4, Osborne-road, Thornton Heath	1
A. Stewart, Worcester House, Walbrook, E.C.	1
G. C. Harrower, College-hill-chambers, E.C.	1
W. R. Harrower, College-hill-chambers, E.C.	1

There shall not be more than seven Directors. The first are Sir Edward N. C. Braddon, K.C.M.G., Charles Barclay, Alfred Mattei, J. W. Syme, and C. H. Grant. Qualification, 100 shares Remuneration: Chairman, £150 per annum; ordinary Directors, £100 per annum each, with 5 per cent on the net profits after payment of 10 per cent. dividend, the latter divisible.

Pioneer Telephone Company, Limited.—Registered by Davies and Sons 9, Angel-court, E.C., with a capital of £100,000 in £10 shares. Object: the general establishment and development of telephonic means of communication, and to diminish the cost thereof, and the adoption of improvements therein; to acquire lands, buildings, patents, business undertakings, etc., for the purposes of the Company; to carry on the general business of a telephone company; to establish and maintain telephonic exchanges; to advance money, to discount and deal in bills of exchange, promissory notes, debentures, and other negotiable instruments; to establish and maintain cables, stations, electric works, factories, and warehouses; to undertake and carry on all kinds of guarantee and agency business; and as company promoters, concessionnaires, and financiers; and to carry into effect an agreement expressed to be made between the Electric and General Investment Company, Limited, of the one part and this Company of the other part. The first subscribers are:

	Shares.
M. B. Praed, 189, Fleet-street	1
The Duke of Marlborough, 3, Carlton House-terrace	1
J. B. Braithwaite, jun., 18, Highbury New Park	1
F. U. Reynolds, Bromley, Kent	1
G. Herring, 1, Hamilton-place, W.	1
C. Braithwaite, 19, Lyndhurst-road, Hampstead	1
J. C. Bull, Broughton Lodge, Surbiton, Surrey	1

There shall not be less than two nor more than 10 Directors. The first are the Duke of Marlborough, Colonel the Hon. Oliver Montague, C. Praed, and F. E. Savory. Qualification, £250. Remuneration to be determined in general meeting. With slight modifications, the regulations contained in Table A apply.

"Electrical Plant, Limited."—Registered by Crouch, Edwards, and Heron, 70, Basinghall-street, E.C., with a capital of £10,000 in £10 shares. Object: to acquire the undertaking of the monthly periodical known as *Electrical Plant*, now carried on at 52, Queen Victoria-street, E.C., by Henry Sherley Price and Wallis Rivers Goulty, in accordance with an agreement expressed to be made between the said H. S. Price and W. R. Goulty of the one part, and this Company of the other part; to print and publish the same, and generally to carry on business as printers and publishers in all its branches. There shall not be less than three nor more than seven Directors. The first are H. S. Price, W R. Goulty, and H. C. Hall. Qualification, £250. Remuneration, £1. 1s. each for each Board attendance.

BUSINESS NOTES.

The Commercial Cable Company announces the payment on April 1 of the quarterly dividend at the rate of 7 per cent. per annum

New Works.—Messrs. Dorman and Smith have established new head offices and works, under the title of the Ordsal Station Electrical Works, at Salford, Manchester.

Dividend.—The Brazilian Submarine Telegraph Company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, tax free, for the quarter ended December 31, 1891, payable on the 25th inst.

City and South London Railway.—The receipts for the week ending 6th March were £893, against £732 for the corresponding period of last year, showing an increase of £161. As compared with the week ending February 28th last week's receipts show an increase of £64.

The Campbell Gas Engine Company, of Halifax, have just opened a branch showroom at 103, Snow-hill, Birmingham. The new premises are lighted by electric light, the dynamo supplying the current being driven by means of a 4-h.p. Campbell gas engine. The branch will be under the management of Messrs. A. and G. Bentley.

Companies Registered during February. — The following electrical companies were registered during the past month:

Electro-Automatic Fire Extinguishing Company, Limited, £1 shares	£12,500
Eston Arc Lamp Syndicate, Limited, £5 shares	25,000
Pioneer Telephone Company, Limited, £10 shares	100,000

Oriental Telephone Company.—The Directors of this Company have resolved, subject to audit of the accounts, to recommend to the shareholders a similar dividend to that paid last year—viz, at the rate of 2¼ per cent. on the entire paid-up capital of the Company—which dividend being only payable to the holders of ordinary shares, is equivalent to £3. 12s. 2d. per cent. on each share of 11s. paid.

Pioneer Telephone Company.—The promoters of this Company were very successful in floating their venture, applications amounting to £82,600 being received for the issue of 7,500 £10 shares offered to the public. We give some particulars as to the first subscribers, etc., to the "Pioneer" under "New Companies." If it succeeds only half as well as its electric light namesake, the Telephone Pioneer shareholders will have no reason to complain.

Electric Construction Corporation.—At a general meeting of the holders of founders' shares in this Company, held last week, the following resolutions, proposed by Mr. J. Spencer Balfour (in the chair), and seconded by Sir Daniel Cooper, were carried unanimously—viz.: 1. "That the capital of the Company be increased to £750,000, by the creation of 25,000 new shares of £10 each, numbered 50,001 to 75,000 inclusive." 2. "That the whole or any part of the said 25,000 new shares of the Company may be issued with any such rights of preference over the founders' shares, whether in respect of dividend (not exceeding a cumulative preferential dividend at the rate of 7 per cent. per annum upon the amounts credited as paid thereon) or in respect of repayment of capital, or both, and with such right of voting, and generally upon such terms and conditions in all respects as the Company may from time to time by special resolution determine." The Chairman explained that they did not intend to raise the £250,000 extra capital at once, but probably only £50,000, or at most £100,000, would be sufficient for their present purposes. The reasons given for asking for this extra working capital were the usual ones—viz., that the Company would then be able to carry out sundry large orders, which were practically only waiting for the wherewithal to do so. Subsequently, a meeting of ordinary shareholders was held, at which resolution No. 1 was put to them and carried unanimously.

PROVISIONAL PATENTS, 1892.

February 29.

3887. **A system of sending and receiving signals on telephone lines for use in fire brigades and other purposes.** Francis Elliott Stuart, Volthurst, Twickenham.

3919. **Improved method of repairing incandescent lamps.** William Stepney Rawson and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

March 1.

3970. **Electromagnetic machines.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Robert Lundell, United States.) (Complete specification.)

3951. **An improved telephonic transmitter diaphragm.** Joseph Slater Lewis, 10, The Avenue, Castle Hill, Ealing.

3971. **Improvements in power-transmitting devices, especially applicable to the electrical propulsion of vehicles.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, London. (Edward Hibberd Johnson, United States.) (Complete specification.)

3991. **Improvements in electrical call and indicating apparatus.** George Richard Nunn, 6, Bank-street, Manchester.

3996. **Improvements in galvanic electric adhesive plasters.** William Phillips Thompson, 6, Lord-street, Liverpool. (John Ward Shults, United States.) (Complete specification.)

3997. **Improvements in reflectors for electric lamps.** Charles Henry Smeeton and Herbert Page, 63, Queen Victoria-street, London

4003. **Improvements in electromagnetic tools.** William Stepney Rawson, Wyndham Payne Gallwey, and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

4010. **Improvements in telephones.** William Chancy Lockwood, 46, Lincoln's-inn-fields, London. (Complete specification.)

4015. **Improvements in electrical devices for stopping and starting horses.** Henry Harris Lake, 45, Southampton-buildings, London. (The Holson Electric Harness and Supply Company, United States.) (Complete specification.)

4017. **Improvements in electric measuring instruments.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward Weston, United States.) (Complete specification.)

4025. **An improved means of effecting electrical communication through the medium of a clock or similar apparatus.** William Hunter Miller, 21, Cockspur-street, London.

MARCH 2.

4068. **Improvements in telephones.** Joseph Birdus Smith Booth and Ernest James Falconer, 70, Market-street, Manchester.

4097. **An improvement in the construction of electric arc lamps.** Edwin Charles Russell, 90, Cannon-street London.

4103. **Electro-deposition of aluminium on metals** Robert Goodwin, 24, Exchequer-street, Dublin.

4111. **An improvement in electromagnetic time and date stamping machines.** John Milton Glover, 52, Chancery-lane, London.

4112. **An improvement in electromagnetic postal, cancelling, time, and date stamping machine.** John Milton Glover, 52, Chancery-lane, London.

4113. **Improvements in electromagnetic time and date stamps.** John Milton Glover, 52, Chancery-lane, London.

4125. **Improvements in electrical circuit arrangements and apparatus for telegraph message signalling.** Frederick Thomas Hollins, 10, Forest-drive East, Leytonstone, Essex

4134. **Improvements in electrical visual signalling apparatus** Cornelius Edward Kelway, 122, St Donatt's-road, New Cross, London.

4152. **Improvements in electro-therapeutic apparatus.** William James Herdman, 45, Southampton-buildings, London (Complete specification.)

4154. **Improvements in electric batteries.** Emile Viarengo, 4, South-street, Finsbury, London.

4157. **Improvements in shades for electric glow lamps.** Henry William Taylor, 53, Chancery-lane, London.

4158. **Improvements connected with electric circuits for varying, regulating, or controlling the pressure of electric currents therein.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

4161. **Improvements in regulating the feed of arc lamps.** Francis Joseph Taylor, 37, Chancery-lane, London.

MARCH 3.

4185. **A new or improved automatic portable galvanic battery.** Peter Stiens, 70, Market-street, Manchester. (Complete specification.)

4186. **An improved slow-speed dynamo.** Sarah Jane Rollason, 50, Goldhurst-terrace, South Hampstead, London.

4190. **Improvements in electrical batteries.** François Marie Arthur Laurent-Cély and Etienne Finot, 2, Great George-street, Westminster, London.

4192. **Improvements in and relating to electric meters.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 16, Red Lion-street, Clerkenwell.

4244. **Improvements in ships' telegraph.** Henry Endall, 76, Chancery-lane, London. (Complete specification.)

4247. **An electrical cut-out.** Henry Sheehy Keating, 28, Southampton-buildings, London.

4248. **Improvements in arc electric lamps.** James Brockie, 28, Southampton-buildings, London.

MARCH 4.

4258. **Improvements in the wearing parts of dynamo-electric machinery.** Wilfred L. Spence, The Elms, Seymour-grove, Manchester.

4277. **An electric motor.** Alfred Edwin Patterson, 65, Galley-wall-road, Rotherhithe.

4276. **Improvements in electrical testing instruments.** Robert William Paul and Frith Knowl, 44, Hatton-garden, London.

4294. **Cross's electrical illuminations for clocks, etc.** Walter Cross, 80, Danby-street, Bellenden-road, Peckham, London.

4311. **Improvements in dynamos.** Willoughby Statham Smith and Henry Joseph Garnett, 24, Southampton-buildings, London.

4316. **Improvements in electric welding and in apparatus therefor.** Ernest Gustave Hoffmann, 55, Chancery-lane, London.

4320. **Improvements in apparatus for regulating the arc in electric arc lamps.** Alfred William Money and Herbert Nash, 23, Southampton-buildings, London.

MARCH 5.

4341. **Improvements in the methods of driving electric railway trains.** Wilfred L. Spence, The Elms, Seymour-grove, Manchester.

4356. **Improvements in electric measuring instruments.** Walter Thomas Goolden and Sydney Evershed, Woodfield Works, Harrow-road, London.

4403. **An electric switch.** William Kirkham Partington, 61, Chancery-lane, London.

4414. **Improvements in and relating to dynamo-electric machines.** Carl Coerper, 45, Southampton buildings, London. (Complete specification)

4416. **Improvements in electric switches.** William Henry Weston and George Washington Weston, 45, Southampton-buildings, London. (Complete specification.)

4427. **Improvements in switchboard systems for telephone exchanges.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.)

4428. **Improvements in switchboard systems for telephone exchanges.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.)

4429. **Improvements in switchboard systems for telephone exchanges.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.)

SPECIFICATIONS PUBLISHED.

1880.

3880* **Distributing electricity, etc.** Jensen. (Edison Electric Light Company's Disclaimer.) (Third edition.)

1882.

3813. **Regulating, etc., electric currents.** Beeman and others. (Second edition.)

1890.

1246. **Electrolytic generation of chlorine, etc.** FitzGerald and Falconer. (Second edition)

1891.

389. **Electricity meters.** Teague. (Second edition.)
4479. **Electrical conductors.** Morgan-Grenville.
4881. **Electric tramways.** Clark. (Sigmund Schuckert and Co)
5461. **Electric traction.** Dickinson.
5715. **Insulating electrical conductors.** Pitt. (Davidson.)
6029. **Electro-depositing copper, etc.** Walenn and Timmis.
6030. **Electro-depositing copper, etc.** Walenn and Timmis.
6318. **Medico-electric batteries.** Mitchell.
6397. **Phonoporic telegraphy.** Davies.
6492. **Electric glow lamps.** Barter.
17310. **Electric signalling.** Von Orth and Breslauer.
19370. **Incandescent electric lamps.** Dunand.

1892.

278. **Electrical conductors.** White and Allam.
645. **Electric welding.** Gendron.
798. **Electrical conductors.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{3}{8}$
— Pref.	—	$2\frac{1}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	20xd.
House-to-House	5	$5\frac{5}{8}$
Metropolitan Electric Supply	—	9
London Electric Supply	5	$1\frac{1}{4}$
Swan United	$3\frac{1}{2}$	$4\frac{1}{2}$
St. James'	—	$8\frac{3}{8}$
National Telephone	5	$4\frac{5}{8}$
Electric Construction	10	6
Westminster Electric	—	$6\frac{3}{4}$
Liverpool Electric Supply	5	5
	3	$2\frac{5}{8}$

NOTES.

Islington.—Developments will take place at Islington shortly.

Northampton.—The cost of lighting the Northampton Town Hall was £1,628.

Bangor.—The question of a fire alarm for Bangor has been referred back to the General Purposes Committee.

Longue.—The Mayor of Longué (Maine-et-Loirè), France, invites propositions for the electric lighting of the town.

Deputations.—On Monday a deputation from the Portsmouth Town Council went round the Crystal Palace Exhibition.

Londonderry.—The Corporation of Londonderry are inviting applications for the position of consulting mechanical engineer.

Transvaal.—The Transvaal Government has given permission to the Sheba Company to lay an electric cable and to erect an overhead tramway.

Oil Engines.—The fourth Cantor lecture by Prof. W. Robinson on "The Uses of Petroleum in Engines," takes place on Monday at the Society of Arts.

Electric Central Stations.—The Corporations of Manchester and of Huddersfield are advertising for tenders for the erection of central electric station buildings.

Telephone Visitors.—The number of visitors registered at the turnstile of the National Telephone Company's telephone-room in the Crystal Palace at the end of last week was 23,221.

Portsea.—The Portsea Guardians at their last meeting were invited by the town clerk, by letter, to consider the question of electric lighting at the union house. The matter was referred to the Visiting Committee.

Electrical Measurement.—On Monday evening Mr. Malcolm Sutherland gave a lecture on "Measurement of Electricity" to the Philosophical Society, Dumbarton. He was awarded a hearty vote of thanks at the close.

Smoking Concert.—The Old Students' Asssociation will hold a smoking concert on Friday, March 25th, at the Mason's Hall Tavern, Mason's-avenue, Basinghall-street, to commence at 7.30 p.m. A first-class programme has been arranged.

Hucknall Huthwalte.—The Local Board at this town are opposing the application of the South Normanton Gas Company for a provisional order for gas, and several streets are to be experimentally lighted with oil. Electric light should be tried.

Edinburgh.—The sub-committee of the Lord Provost's Committee of the Edinburgh Town Council in charge of the electric light last week instructed the city law agent to report on the powers of the Corporation to delegate conditionally their powers with regard to electric lighting.

The Chatham Accident.—Sir M. Hicks-Beach, questioned by Mr. P. O'Brien in the House of Commons on Monday as to the death at Chatham of a man named Albert George Jay by electric shock, stated that the electric light company had been requested to make alterations.

Johannesburg. — The Transvaal Government has refused to consider the claim for £28,000 made by the Johannesburg Electric Lighting Company in respect of the lighting of Johannesburg under a Government contract; and the company has accordingly withdrawn all rights to such a claim.

Preston.—Tenders by builders and contractors are invited by the National Electric Supply Company, Limited, up to 24th inst., for works connected with central lighting station at Preston. Specification and plans on application to Mr. R. A. Came, 27, Mecklenburgh-square, London, W.C., architect.

Recorders.—Dr. C. Theodore Williams, president of the Royal Meteorological Society, in his address referred to MM. Richard Frères as "the recording angels of the nineteenth century"—if anything happened in the meteorological world, they immediately invented an instrument to record it.

Brighton.—In the proceedings of the Brighton Lighting Committee, before the Town Council last week, the Council were asked to accept Messrs. Siemens Bros. and Co.'s tender to supply the required cable with a resistance of 1,000 megohms per statute mile for the sum of £2,230—part of a sum which the Council had already sanctioned to borrow for the work. This was sanctioned.

St. Pancras.—Mr. Oswald John Simon, writing to the *Times* on Friday, complains of the inconvenience of the arrangement of the electric lamps belonging to the St. Pancras Vestry at the junction of Tottenham Court-road and Euston-road. When a large waggon comes along it is impossible for other vehicles to pass. He invites the Vestry to take steps to remove or lessen the inconvenience.

Royal Society.—Papers were read before the Royal Society on Thursday by Dr. Hopkinson, F.R.S., and Ernest Wilson on "Dynamo-Electric Machinery," dealing with important problems of dynamo construction as illustrated in the construction of the King's College dynamos. A paper was also read by Mr. R. T. Glazebrook, F.R.S., and S. Skinner, "On the Clark Cell as a Standard of E.M.F."

Pontypridd.—At the meeting of the Pontypridd Local Board last Friday, a letter was read from Messrs. W. H. Morgan and Rhys, solicitors to the Pontypridd Electric Light Company, stating that they were prepared to light the centre of the town as shown in a plan which was enclosed in their letter. The consideration of the matter was deferred, pending the result of the negotiations for the purchase of the gas works by the Board.

Sheffield Telephone Exchange.— The business of the Sheffield Telephone and Electric Light Company is, it is understood, about to be acquired by the National Telephone Company. Negotiations have been in progress for some time, and terms are now practically settled. It is understood that the business will be taken over as from the end of the present month. On the part of the National Company the statement is made that there is no disposition to raise prices.

Harrogate. — At the Harrogate Town Council on Monday, the question of putting into force the provisions of the electric lighting order was considered, and it was resolved that a sub-committee, consisting of the Mayor, Aldermen Fortune and Hammond, and Messrs. Hudson, Oxley, Simpson, and Thwaites, be appointed to make enquiry as to the best means of supplying the light in Harrogate, and, for that purpose, to inspect the installations of the light in other places.

Longest Span in England.—The span of the telephone wire over the River Dart, connecting Dartmouth with the trunk lines between Torquay and Plymouth, is 2,400ft. The wires, of silicious bronze, 17 in number, which cross the Dart, were erected in May, 1889, and the span was described by us at the time. It is some guarantee of their stability, and some credit to the Phosphor Bronze Company, who supplied them, that they have well stood

the strain of the blizzard of last year and the recent heavy gales.

Weston-super-Mare.—At the monthly meeting of the Weston-super-Mare Town Commissioners, a letter was received from the Local Government Board, in reply to the clerk's application for sanction to borrow the amount of costs incurred by the Local Board in connection with obtaining the Weston-super-Mare Electric Lighting Order, 1891, stating that it did not appear to the Local Government Board that the Commissioners had any power to raise a loan to meet the costs of obtaining the provisional order in question.

Electric Boats.—Three electric boats are being sent off this week by the General Electric Traction Company for use on the Manchester Ship Canal. The company have four electric boats in hand, one being a launch for Lord Dysart, the second a repeat order from another gentleman; the others are fresh boats for the Thames service. Quite a flotilla of these boats will be sent to Barnes for the University Boat Race, and many others, if they were built, could be hired out. Mr. George Newnes has rented the "Viscountess Bury" for the boat race.

Aberdeen.—At the meeting of the Aberdeen Town Council last week, the Gas Committee reported that they had appointed the convener (Bailie M'Kenzie), Bailie Nicol, Messrs. Bisset and Johnston a sub-committee to obtain and submit information in regard to the systems of electric lighting in those towns where it had been introduced, with powers to visit such of the towns as might be deemed expedient, and take such professional advice as they might think proper. After considerable discussion the report was adopted by a large majority.

Glasgow.—The Corporation of Glasgow has commenced operations for the establishment of the central electric station for supply of electric light to the city. The site of the station is at the corner of Waterloo and Main streets, and in addition to its erection and the fitting up of the requisite plant, there are 13 miles of mains to be laid. It is understood that there is already a good enquiry for the light by leading warehousemen. Notwithstanding these operations, it has also been found that the Dawsholm Gas Works at Maryhill will require to be enlarged.

Sittingbourne.—The new large mill at the *Daily Chronicle* paper mills, Sittingbourne, owned by Messrs. Lloyd, has been lighted by electric light. The plant consists of two dynamos driven by a 160-h.p. engine. The lamps vary from 16 c.p. to 50 c.p. A soft, clear light is diffused over the whole place, affording a marked contrast to gas. The system has given every satisfaction, so much so that the firm intend, at no very distant date, to develop it. It is not improbable that the town itself may be lighted by means of electricity, suggestions to this effect having been made in more than one quarter.

Railway Clearing House.—Tenders are required for wiring and fittings for electrically lighting the two blocks of buildings situate in Seymour-street, Euston-square, London, known as the Railway Clearing House, for the Committee of the Railway Clearing House. Specifications, schedules, and plans may be obtained on application to the secretary, on payment of one guinea. Tenders, marked on the outside of the envelope "Tenders for Electric Lighting," are to be delivered at the office of Mr. H. Smart, secretary to the committee, the Railway Clearing House, Seymour-street, Euston-square, before 11 a.m. on 30th inst.

Cork Tramways.—The report of the city engineer, Mr. McMullen, on the proposed tramways was submitted in detail at the last meeting of the Cork Standing Committee. The length is 7 furlongs 51 chains; the line will be of 3ft. gauge, using steel rails of girder section 60lb. to the yard in 30ft. lengths. The rolling-stock will consist of one-horse cars capable of carrying 24 passengers. The notice accompanying the plans stated that it is intended to seek for power to authorise the company to use horse, electrical, steam, or other mechanical power. The city engineer recommends that if electrical traction be used, it shall not be with overhead wires. The plans were approved.

Nuneaton.—At the meeting of the Nuneaton Local Board on Wednesday, the chairman drew attention to the fact that the Board's power to compulsorily purchase the gas undertaking from the private company in whom it was now vested would shortly expire. Several members considered the works ought to belong to the town, but there was a general complaint as to the bad quality of the gas that had for some time past been supplied. Mr. Butlin said that the matter was one which required serious consideration; taking into account the high price charged for gas, it was an open question whether the electric light could not be supplied more economically. The matter was adjourned for a month.

Electric Supply.—A curious circumstance is to be noticed in the returns of consumption of the Kensington Court station. The income per lamp has gone down from 10s. per lamp in 1890 to 9s. per lamp last year, a result that can only be explained by the theory that the public are becoming more habituated to the use of the electric light and take more care in turning it off when not wanted. At the same time, however, the total income has gone up with but little increase of cost—nearly three times the profit has been made with an increase of cost of only one-quarter. These facts, showing reduction in the cost to the consumer, and also in the relative cost of production to the company, are favourable auguries for the future progress of the company.

Worcester.—A meeting of the Worcester Watch Committee was held last Friday. The town clerk presented the report of Mr. W. H. Preece, F.R.S., who had been consulted by the committee for the consideration of the tenders for supplying electric light to the city. It stated that 15 tenders had been sent in from first-class firms, who had submitted very complete and practical plans. After enumerating the different firms and their methods, on the motion of Alderman Hill, seconded by Mr. Williamson, it was resolved to adopt the report, and to recommend the Council to accept the tender of the Brush Engineering Company for lighting the city by electricity. The tender was £20,030. It was stated that the annual working expenses were estimated at £3,150.

Electric Cooking.—Cooking by electricity is becoming, as we prophesied, quite the fashion. We notice that the proprietor of the Eldon Dining Hall and the Pine Apple Grill at Newcastle-on-Tyne has had trials of this novelty in cooking. At the former place on Friday some cutlets, and at the latter on Saturday a thick chop, were cooked by this new process—the cutlets in seven minutes and the chop in 14—to the entire satisfaction of the manageresses and *chefs*. We believe electric cookers are being fitted in several of the West-end flats in London. They deserve to be widely adopted. Mr. Dowsing's demonstrations every day at the Crystal Palace will greatly foster this cleanly and easy method of cooking. This will make more filling-up for station engineers' "load diagram."

Electrical Exhibition for Manchester.—A correspondent of the *Manchester Guardian* has a suggestion which, when the time arrives, should be given attention. He does not like, he says, this electrical exhibition business being confined to London. There ought at once to be an

electrical exhibition in Manchester, with the power generated by water power and transmitted to the exhibition. He does not say where from, but a few miles more or less now does not make much difference. "We really want," he says, "more development of electricity in Lancashire," and we think he is right. There is an enormous field for its utility in the cotton district—for light, for heating, and for traction and power transmission. Perhaps the exhibitors will combine and transfer their exhibits to Manchester at the end of this Exhibition.

Arc Lamps for Stations.—The new buildings in course of erection at the Glanmire terminus of the Irish Great Southern and Western Railway will not be provided with electric light. The flickering or intermittent character of the light renders it objectionable, think the directors, for station illumination, and it has been discarded in favour of gas. It is not proposed to interfere with the present system of lighting the outside works of the station. The electric light will be continued there as heretofore, we are told, as nothing can equal its brilliancy and efficacy for conducting the extensive and dangerous work of a railway terminus. If it is simply a question of flickering that prevents the use of electric light for the station, the directors might do well to investigate the merits of the Brockie-Pell arc lamp, which has shown its capabilities for absolute steadiness in many important installations.

Crystal Palace Jury.—The following gentlemen have kindly consented to serve on the jury for the Crystal Palace Electrical Exhibition: Prof. W. Grylls Adams, D.Sc., F.R.S., Prof. W. E. Ayrton, F.R.S., Mr. Shelford Bidwell, M.A., F.R.S., Mr. Conrad Cooke, M.I.E.E., Prof. W. Crookes, F.R.S., Mr. W. B. Esson, M.I.E.E., Major-General Festing, R.E., F.R.S., Prof. George Forbes, M.A., F.R.S., Captain Sir Douglas Galton, K.C.B., D.C.L., F.R.S., Dr. J. H. Gladstone, F.R.S., Mr. J. H. Greathead, M.I.C.E., Mr. Charles Hall, M.I.E.E., Prof. D. E. Hughes, F.R.S., Sir Henry Mance, C.I.E., Mr. W. H. Massey, M.I.C.E., Mr. W. H. Preece, F.R.S., Mr. A. Reckenzaun, M.I.E.E., Prof. Henry Robinson, M.I.C.E., Captain Sankey, R.E., M.I.E.E., Mr. C. E. P. Spagnoletti, M.I.C.E., Mr. James Swinburne, M.I.E.E., Prof. Silvanus Thompson, D.Sc., F.R.S., Mr. J. Tomlinson, M.I.C.E., Prof. W. C. Unwin, B.Sc., M.I.C.E., Major-General Webber, C.B., R.E., Mr. J. W. Wilson, M.I.C.E.

Electric Tanning.—The other day we received a pamphlet of the Worms et Balé process of electric tanning. We have now received the pamphlet of the rival system—Groth's tanning system—from the Chevalier Lorentz Albert Groth, 3, Tokenhouse-yard. In this system, which has been worked out at the Grange Works, Bermondsey, the hides are carried in a revolving tub or on a frame moving to and fro in a tanning liquor in which electric conductors are inserted. The rate of tannage under combined motion and electricity was four times faster than with motion alone and sixteen times faster than when neither are used. The pamphlet contains a large amount of information, with description of process and diagrammatic curves, embodying the results of the experiments, and is evidently likely to be of considerable interest, not only to leather dealers and tanners, but to all who pay attention to the practical applications of electricity. We understand the electric-tanned leather is now put on the market.

Basingstoke.—At the monthly meeting of the Basingstoke Town Council, Mr. Smith moved: "That in the opinion of this Authority, the public lighting of the town is inadequate, the charges for such lighting excessive, and that the Lighting Committee should take immediate steps to ascertain the cost of lighting it with the electric light; and that the sum of £25 be granted to them to meet the expenses of such enquiries as they may consider necessary to make." He went at length into the advantages and saving of money that would accrue if the electric light was adopted, and argued that they ought to have a better system of lighting the town than they had at present. Nearly every member of the Board spoke in favour of the resolution, with the exception of the clause relating to the expenditure of £25, and Mr. Simmons suggested that that clause should be expunged, and that the committee should report to the Board the result of their enquiries. This suggestion was ultimately accepted, and the motion as amended was approved.

Madras Tramways.—A company is being formed, with a capital of £100,000, to take over the concession granted by the Madras municipality to Messrs. Wm. Hutchinson and Co., Madras and London, for right to run electric tramways. The total length of line is 15½ miles, of which six miles must be completed with two years. It is hoped to get part of the line running within 12 months. It is expected that the line, plant, and buildings will be provided for a sum not exceeding £5,000 per mile. All material possible will be made locally. The company has applied for powers also to supply electric light for the streets, public buildings, and residences in Madras. There is no gas in Madras. Lord Wenlock, Governor of Madras, cordially approves of the project. The directors are Wm. Digby, C.I.E., chairman; M.M. Bhownuggree, C.I.E., A. J. Lusty, and S. A. Chalk, managing directors. The municipality reserve the right to purchase at the end of 21 years on payment in gold of the gross capital, with 25 per cent. added for compensation.

Meteorological Exhibition.—The exhibition of the Royal Meteorological Society includes a number of interesting instruments. Besides rain-gauges and other instruments for a station, thermometers are also shown for ascertaining the temperature on the ground, under the ground, and at a distance, as well as for recording temperature continuously. Various forms of sunshine recorders are exhibited, as well as a number of actinometers and solar radiation instruments for ascertaining the heating effect of the solar rays. The exhibition includes a large and interesting collection of hygrometers, also several rain-gauges and other instruments. Among the curiosities is a piece of plate glass which was "starred" during a thunderstorm on August 21, 1879. This was not broken, but it has a number of wavy, hair-like lines. The exhibition contains a large number of beautiful photographs of clouds, lightning, and snow scenes, as well as of the damage done by the destructive tornado at Lawrence, Mass, U.S.A. The exhibition will remain open until Tuesday, the 22nd inst.

Arc Lamps and Shades.—There is a considerable difference in the direction of light radiation from an arc lamp run on the direct-current and that from a lamp run on the alternate-current system. The difference does not seem to be appreciated by a contemporary priding itself on its popular illustrations, where the light from the arc lamps in Tottenham Court-road is seen bursting upwards very wastefully. The occasion may serve for a remark upon the use of shades and reflectors. In most cases an arc lamp run on a continuous-current circuit will be found not to require a reflector at all, as can be tested if practical trials of the loss of light are made. In an arc run with continuous current, the upper carbon forms a crater which effectually cuts off or reflects down by far the greater portion of the light, thus practically obviating the necessity for reflectors. In arcs fed by

the alternate current, on the other hand, both carbons become pointed, and the light is reflected in all directions; the necessity for a reflector in this case therefore becomes important.

Instruments and Switchboards.—We are favoured by Messrs. Nalder Bros. and Co., of 16, Red Lion-street, Clerkenwell, with their catalogue of ammeters, voltmeters, and switchboards. This shows ammeters and voltmeters of high finish and open scale for central station use, both for direct and alternate currents. A cell-testing voltmeter with spear for making contact, reading up to three volts, can be read in any position. A portable testing set for making pass tests of house installations is conveniently arranged, and a larger portable testing set with galvanometer and resistance coils adjusted approximately is specially designed for electrical contractors, self-enclosed in box. A standard voltmeter potentiometer is designed for making accurate station tests for actual measurements or for calibrating voltmeters. Holmes and Vaudrey's automatic solenoidal cut-out is designed for use with dynamos charging accumulators, or two dynamos in parallel, to complete or break the circuits when the pressure rises or falls to the required point. Resistance frames and complete switchboards are also shown.

Ludlow.—Last Friday a public meeting was held in Ludlow, Alderman Bessell presiding, to receive from the chairman and secretary of the British Electric Installation Contractors, Worcester, particulars of the requirements for carrying out an installation at Ludlow. Mr. Millington, chairman of the company, said he estimated the capital required to work the scheme at £3,500, and there would be some 2,000 lights. He calculated that the lights, at 12s. per year, would bring in an income of £1,200. The working expenses would be about £670, leaving a margin of £525. The company was proposed to be started with £1,000 debentures, 6 per cent., and ordinary shares. He recommended a storage system. The cost of installation per light would vary from 12s. to 15s. per light or more, according to fittings used. In reply to Mr. Valentine, Mr. Millington said his company would provide £1,500, the other £2,000 to be subscribed by the town. The public lighting could be carried out considerably cheaper than the present price of £300. Mr. Valentine proposed a vote of thanks to Mr. Millington, and said he hoped those gentleman present who were interested in the scheme would send in their names to form the company. Mr. Bessell seconded the resolution, which was carried.

Fire Alarms.—The order from the Poplar Board of Guardians to extend the fire alarm system throughout the two newly-built blocks, and to rewire the present system in the old buildings of the Poplar Workhouse, has just been completed by Mr. H. Hugh Headworth. The work is of a thoroughly substantial character, the wire being of the well-known Silvertown make, No. 18 indiarubber and cotton-covered, of which a mile and a quarter has been used. The whole of this is run in wood casing, with the exception where the circuits pass through walls and floors, where the wire is protected by rubber tubing. Junction-boxes with glass fronts are fixed at the junction of all main branches for the purpose of any future testing that may be required — a special and convenient arrangement. The alarm calls are of the usual bright-red enamelled iron, with fire alarm cast on, and glass fronts. These are fixed, one on each of the landings of the main staircases, access to which is open to all—a decided improvement on the system of the old buildings, where the alarm calls are fixed in the officers' rooms, and are therefore not accessible to any of the *inmates*. An indicator shows from which block the alarm has been given, the whole making a very complete fire alarm system.

Deptford Station.—The Deptford central station suffered an accident on Thursday, last week, which we were just too late to mention in our last issue. About 4 o'clock the lights began to flicker, something was noticed wrong, and the men at the station switched over to another set of mains. These went, and all four went one after the other. The natural conclusion for a while was that a railway accident down the line had torn the cables, but a workman travelling by the train arrived with the information that a fierce fire was raging down the line. It appears that Messrs. Martin and Co. use one of the railway arches as a varnish store, and this accidentally took fire while the man in charge was away, and completely gutted the premises. So fierce was the fire that the telephone wires opposite were burnt through, and the Ferranti mains were made white hot. The fire soon burnt itself out, and the telephones were got to work by 10 o'clock, and the Ferranti mains an hour later. This accident, evidently due to no fault of the London Electric Company, is the first of any kind they have experienced for four months, either in mains or transformers. They have been working with 10,000 volts since February last year. The number of lamps connected is now over 40,000. The report of the directors may be expected shortly.

Weaving by Electricity.—The City Council of St. Etienne has decided upon a departure which will have an important effect on the silk and ribbon industries both in Europe and in America. It has been resolved to apply electric motive power to all the handlooms in the city, and contracts have been made, says the *Manchester Examiner*, with an electric company for the necessary plant and currents. The electric dynamos are to be driven by water from the city reservoirs. There is practically an unlimited supply of water in the reservoirs, with a fall of upwards of 100ft. The cost of producing the electricity will be reduced to the lowest point possible. To grasp the importance and far-reaching results of this innovation, it is necessary to understand that the bulk of the enormous output of ribbons (£4,500,000 a year) is the product of house industry. The weavers for the most part own their own looms, and operate them by hand in their own houses. There are 18,000 looms which are thus distributed among the homes of the weavers, while the number of looms driven by steam in the few ribbon factories of the town is only 5,000. The 18,000 looms of the independent weavers are valued in the aggregate at £900,000. What the city of St. Etienne proposes to do is to convert each one of the 18,000 handlooms into a power loom, driven by electricity. Electric light will also be furnished. The result of this change from slow, laborious, uncertain hand power to the swift, regular, unfailing power furnished by electric motors will be an increase in the productive capacities of the looms and a considerable reduction in the general expenses of fabrication. According to the report of the American Consul, the weavers of St. Etienne have always been the most artistic ribbon-makers in the world, but they have enjoyed few mechanical advantages. Now the old order of things is to be changed, and the products of the St. Etienne ribbon looms, which have been more costly than similar products in some other countries, notably in Switzerland, will be turned out at the lowest possible prices. The workpeople employed in the ribbon trade number 70,000.

Electric Spark Photography.—The Saturday Art and Science lecture at the South Kensington Museum was delivered last week by Mr. C. V. Boys, F.R.S., on "Electric Spark Photography as Applied to Flying

Bullets and other Rapidly-Moving Bodies." The spark is generated by the discharge of a Leyden jar, there being in the conductor from it two breaks, which together the electric fluid has not pressure sufficient to jump. But when the bullet or flying object makes contact with one the spark is instantly emitted from the other. As, then, the duration of this spark may be even much less than the one-millionth of a second, it is far and away in excess of the speed of the bullet, which consequently appears to be stationary, and a very precise view is accomplished by the camera. This view records the form of the bullet, its direction and inclination, the balling up of the air in front of it, the long drawn-out vacuum in the air behind it, and the various wave vortices and contortions of the surrounding atmosphere through which it is passing. Photographs of actual experiments were then enlarged into gigantic pictures on the screen, and made perfectly clear in all their singular details to the audience. Some of the most remarkable were those which showed the passage of a bullet through a sheet of plate glass. In one the head of the bullet was seen protruding, carrying what seemed to be a dark cloud of lead vapour, caused by fusion in the impact, and another showed the storm of dust from the smashed up glass; whilst others gave views of the strains set up in the glass plate around the clean perforation the bullet had made. Clean perforations of this nature have long been known, but the reason is rendered additionally clear in that the speed of the bullet exceeds the speed at which cracks in the glass can progress. The result, consequently, is that the round portion of glass in front of the bullet is locally pounded into powder before the exterior portions have time to start into motion. Some notice was also taken of the effects of the dust and vapour envelopes of the bullet in the transmission of sound, and also how, by a series of differently-inclined diagonal perforations through the bullet, and the capacity of light being seen through them, the effects of rotation might be observed, and details of the differences of spin effected between that given by the barrel and those produced in the rapid passage of the missile through the air.

Electricity on Board Ship.—Mr. T. Crichton Fulton lectured last Friday to members of the Rutland-place Marine Engineers' Institute on "Electricity on Board Ship." Prof. Jamieson, who presided, in introducing the lecturer, said he remembered the first exposition of incandescent lamps in 1881 by Mr. Joseph W. Swan, the British inventor of the incandescent lamp, and in the summer of 1881 the wiring and lighting of part of the first steamer fitted with the electric light on the Clyde—the Cunard steamship "Servia." Since then electric lighting on board ship, as well as elsewhere, had increased rapidly, and by nobody was it more appreciated than by the passengers, officers, and crew of ocean steamers. The lecturer, after explaining the nature and peculiarities of the two forces—magnetism and electricity—proceeded to deal with his subject under two divisions: (1) how electricity was obtained; and (2) what was done with it afterwards. Under the first head he showed the relation which existed between magnetism and electricity, the production of a magnetic field by a current, and of a current by the motion of a magnet near a coil. The conditions necessary for the purpose of producing a current of electricity were therefore a magnetic field, a closed conductor in the field, and a mechanical means of causing the conductor to cut the lines of magnetic force in the proper way. He then explained the plant requisite on board ship, and mentioned the conditions essential to success. In the second division of his subject Mr. Fulton spoke of the work required of the current, and showed how it could light lamps, both arc and incandescent; drive electromotors for various purposes, and charge storage cells. The question of circuits was fully dealt with, Mr. Fulton incidentally emphasising the necessity of having all joints and connections well and carefully made. In speaking of the controlling, regulating, and measuring of the current, the lecturer explained the construction and action of switches, fuses, and resistance coils, as well as of the usual measuring instruments—the voltmeter and the amperemeter. The lecture was illustrated by numerous experiments, wall diagrams, and blackboard sketches. At the close Mr. Fulton was awarded a vote of thanks. An "Electrician," writing to the *Glasgow Herald* next day with reference to the introductory remarks by Prof. Jamieson, who stated that the first steamer fitted with the electric light on the Clyde was the Cunard steamer "Servia" in 1881, says this is not correct, as the steamer "Cosmos," built by A. and J. Inglis in 1879, had a complete installation of electric light throughout.

Electric Tramcars at Bradford.—As we mentioned last week, experiments with electric cars are about to be tried at Bradford, and the following particulars with reference to this line will be of interest. Some time ago the Tramways Committee of the Bradford Corporation decided to contribute a sum of £500 towards the cost of a trial of an electric system of traction invented by Mr. Holroyd Smith, of Halifax, and arrangements have been made for putting it to the test on a section of the Manningham tramway, extending from Forster-square to Manor-row. The method to be employed in the traction of the car is that of overhead wires; but this is not to be a permanent arrangement, as, if the motive power is found sufficient for the purpose, it is intended to adopt an underground system. The electric current, as it passes along the overhead wires, is communicated to two brass bars fixed at the top of the car. These are held up by galvanised stanchions, which have short indiarubber springs to allow the bars to relieve any sudden obstacle, and still maintain the necessary contact with the overhead wires and retain the current, which is transmitted by insulated wires enclosed in a tube at each side of the car, to the motors at the bottom of the car. The electricity will be supplied from the Bradford Corporation electrical works in Canal-road, and the motors on the car will be of 36 h.p. The overhead wires are three-eighths of an inch in diameter, and are made of the finest copper. The car, which is capable of carrying 36 passengers (18 outside and 18 inside), is the first of its kind that has been built in England, and has been constructed by the Lancaster Carriage Company from a design of Mr. Holroyd Smith. The weight of the body of the car is 2½ tons, but with the electrical mechanism beneath it the total weight is 6½ tons. The car has only four wheels, but to obviate stress in turning a sharp curve, the wheels of the car are fitted with flexible axle-boxes, which are capable of giving a lateral movement, and thus reducing the grinding movement from the wheel flanges to the rails. Special switches for the engineer and conductor are fixed to the car. One of these consists of a wheel similar to the one which controls the steering gear of a steamer, and by its use the engineer can regulate the current, which can be transmitted to each of the motors underneath the floor of the car. The conductor has thus full control over the current in each motor, and is able to avoid unnecessary waste of power. Each wheel is acted upon by the motor, so that if one is out of order it will still be possible to run the car. Special interest attaches to the experiment on account of the steep gradient on the Cheapside portion of the route, and the sharp curve from Kirkgate.

THE CRYSTAL PALACE EXHIBITION.

I.—THE TELEPHONIC EXHIBITS.

The small practical advance that has been made on Graham Bell's telephone, considered as a receiver, since it finally left his hands in 1878, is remarkable, and testifies eloquently to the degree of perfection to which it had at that period already attained. Most inventions develop slowly and, as a rule, owe their ultimate efficiency to many minds, but the telephone is an exception; it is the Pallas amongst important inventions, and practically sprang perfected from the brain of its creator. Many modifications and alterations have been tried in almost every country in the world, but it is not too much to say that were all these swept out of existence and nothing but Bell's 1878 receiver left, we should be, in a telephonic sense, practically where we are to-day. The superiority of the Ader, of the Siemens, of the Ericsson, is found in actual work to be mostly imaginary, and such difference as exists may generally and correctly be ascribed to the better workmanship and more accurate fitting of parts attendant on prolonged experience. Of the transmitting portion of the apparatus, the same may almost be said. Reis, Gray, and Edison, as Reis and the Wrays had done with the receiver, no doubt indicated the general direction of, and even travelled some distance towards, the wished-for land, but it was Hughes who was the actual Columbus, and who with his microphone, also in 1878, finally piloted us to *terra firma*. Crossley and Hunnings and Blake merely showed that the newly-discovered country contained several parishes: they found nothing beyond the borders of Hughesland.

It is this completeness of success on the part of the original explorers which explains the unsatisfactory character, as regards novelty, of the telephonic exhibits at all the recent electrical exhibitions. Edinburgh and Frankfort showed us nothing new, and Crystal Palace II. is more disappointing than either. In telephones proper there is little that has not been described many times before, so that such novelties as there are relate only to signalling, switching, and construction appliances. Even this section is incomplete. The Post Office shows nothing, and important firms like Bullers, Limited, are only noteworthy from their absence. The exhibit of the National Telephone Company, from which better things might naturally have been expected, contains not a single novelty, and is chiefly an assortment of very familiar apparatus, comprising some spoils of the law courts in the shape of instruments seized from luckless infringers.

The Western Electric Company, as befits the position which, under the able management of Mr. J. E. Kingsbury, it has assumed in this country, makes one of the best telephonic exhibits. Its transmitters and receivers, of several types and excellent workmanship, are well known, and call for no special notice. It is otherwise with the switchboards, of which three different patterns are shown. The first is the company's Standard board for 100 subscribers, with the latest improvements. The old objection of having to speak through the coils of the ring-off drop is now avoided by utilising the plan, first introduced by Mr. J. Poole at Manchester in 1880, and afterwards adopted by the Post Office at Newcastle and Bennett in Scotland, of placing the drop in derived circuit. It is satisfactory to note that American practice is now following British lead in this important particular. Poole managed with a shunt of only 100 ohms resistance, but the Western Electric apparently find it advantageous to wind their coils to 1,000 ohms in addition to making the drop an iron-clad one, precisely as Faulkner did many years ago with his "altandæ" electromagnets.* The new ring-off indicator has but one coil, which is provided with an iron casing in magnetic connection with the core. The armature is an iron disc covering both core and casing. Fig. 1 shows the general arrangement, A being the armature to which the catch, C, is joined by an arm extending the whole length of the coil, and S the shutter. With the long arm a small play of the armature suffices, and the drop is therefore sensitive. The spring-jacks, of the usual Western Electric type, are mounted on ebonite, a by no means unnecessary refinement, seeing that the earlier Standard boards sometimes suffered from defective insulation between the jacks. The method of wiring adopted is noteworthy. The indicator connections behind the board, though of small wire, are sufficiently stiff to stand out fully 4in. from the shelves, those on the same line being bound neatly together, a plan which enables any disconnection to be detected at a glance and readily repaired. Fault-finding is further facilitated by employing a differently-coloured wire for the jack connections. Terminal screws are abandoned in favour of soldered joints, another concession to British ideas.

Fig. 1.

The board is handsomely got up and admirably adapted to exchanges, worked on the indicator system, ranging up to 200 subscribers. Its one defect is that there is no means of enabling the operator to distinguish between a "ring-off" and a "ring-through." The number of movements required to make and then take off a connection on this board is eight—viz.: 1. Plugs into calling subscriber. 2. Pulls down speaking key. 3. Plugs into called subscriber. 4. Rings. 5. Puts up speaking key. 6. Puts up shutter. 7. Pulls out plugs. 8. Puts up ring-off shutter. Another good switchboard shown is of the pattern known as the Scarborough, also for 100 lines. In general construction it much resembles the Standard type, but differs from it essentially in the ring-off arrangements, although the variation cannot be regarded as an improvement, seeing that the coils of the ring-off drop are looped directly into the line when a connection is on. Separate ring-off drops are dispensed with, that of the calling subscriber being utilised for the purpose—the called subscriber's indicator being cut out by a special construction of the switch plug used for his jack. The number of movements with this board is also eight, and they are identical with those required for the Standard. The exhibit of switchboards is completed by a section of Scribner's single-

Fig. 2.

cord multiple, the patents of which are held by the Western Electric Company. The idea of this, as of all other single-cord boards, is to save time in operating by reducing the number of movements required to establish and then take off a connection, although the success attained is not usually very noteworthy, and is more than neutralised by the complication involved. The first single-cord board was introduced about 1879, in New York, in connection with the Law switching system. On the Law board each subscriber's line terminated in a cord and plug, and was also furnished with a jack. It followed that a connection could be established by lifting the plug of the calling subsciber and inserting it in the jack of the called, or *vice versâ*. The simplicity thus attained was considerable, because the Law system required no indicators; when these and cut-in keys are added, as

* *Journal, Society of Telegraph Engineers*, p. 153, vol. v., 1877.

is inevitable with any other system than the Law, simplicity flies and all practical advantage disappears. These facts are fully recognised by the Western Electric Company, which recommends its ordinary double-cord board when saving of movements is not esteemed of the first importance. The motions required for the single-cord—six in number, omitting the engaged test, which is rather a prolonged than a separate action—are: 1. Lifts caller's plug (this act makes the operator's speaking connection). 2. Plugs into called subscriber. 3. Rings. 4. Puts up shutter. 5. Takes out plug. 6. Puts up ring-off shutter. The corresponding work with the double-cord board (also omitting the engaged test) requires eight movements. The Scribner board is remarkably compact, 100 jacks occupying a space only 10½in. by 2¾in., and 40 indicators 14¼in. by 5¼in. As in the Scarborough, the ring-off coils have to be

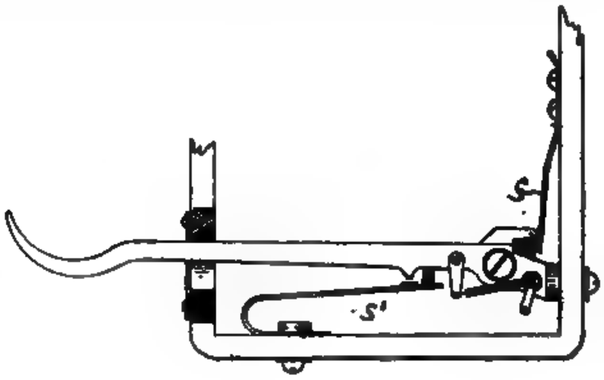


FIG. 3.

talked through by subscribers, and the operators have no means of knowing, when the drop falls, whether the conversation is finished or one subscriber is merely ringing the other. These are blemishes which must disappear before telephonic switching can be admitted to have reached its highest level. Many excellent instruments make up the exhibit. Amongst these, a handsome table set, Fig. 2, of new design is conspicuous. The transmitter, a modified Hunnings, may be turned in any direction; the receiver is of the company's well-known double-pole type, and the magneto is fitted with the latest American pattern of switch arm, Fig. 3, the chief characteristics of which are the length of leverage and the reciprocal action of the springs, S S¹, which alternately assist each other to make contact according to the position of the arm.

twisted wires. The new, or "dry core," cable is understood to be already in very extensive use in the United States, where it is employed in preference to the older type of Western Electric cable, which was insulated with dessicated cotton soaked in paraffin.

Messrs. Anders Elliot and Chetham-Strode, Limited, show a variety of telephonic instruments, some of which are of novel and ingenious design. Microphones are generally supposed to be efficient in proportion to the number of pencils they contain, but we have here a single-pencil transmitter which acquits itself very creditably. The pencil, P (Fig. 4), is mounted horizontally on the two

FIG. 6.

carbon blocks, B B¹, which are firmly attached to the ebonite diaphragm, D. The efficiency of the instrument is due to a carefully adjusted weight, W, in disc form, which is fixed to the middle of the pencil and prevents it from jumping from its seats in the blocks. The simplicity and cheapness of the transmitter recommend it for small private installations. Machines for obtaining telephonic connection from Call Offices by means of penny-in-the-slot arrangements have multiplied exceedingly since Messrs. W. Emmott, J. J. Mann, and J. Poole started the idea almost simultaneously in 1884. Some of these are good, though most are indifferent, but few, if any, in either category, can compete in simplicity with the little instrument exhibited by this firm, and illustrated in Fig. 5, which shows the apparatus in two positions. The exchange can only be called by effecting

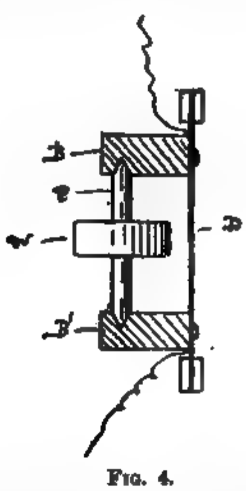


FIG. 4.

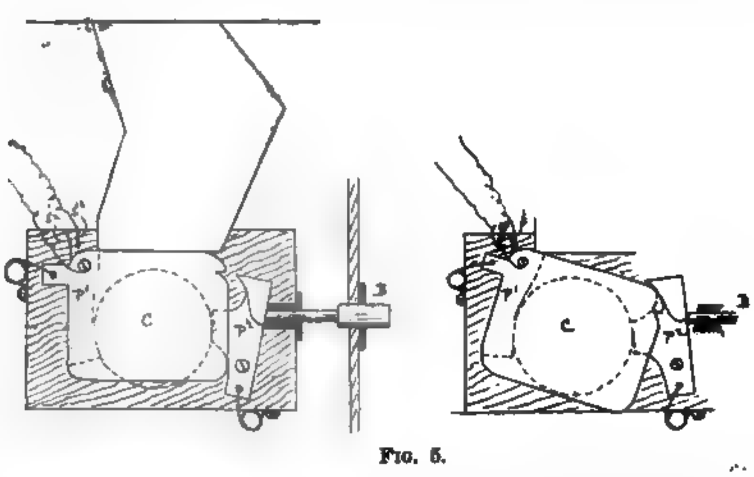


FIG. 5.

Not the least interesting are the samples of telephonic cables manufactured by the Western Electric Company. The recognition of the great importance of low inductive capacity in telephone work has induced the preparation of a new cable, which, with a conductor of No. 18 American gauge, is guaranteed to test only ·085 microfarad per mile. The wires are wrapped with specially prepared paper, which forms the only insulation, and are twisted in pairs and drawn into a tube of lead slightly alloyed with tin. The tube is hermetically sealed at the ends to prevent access of moisture, and sometimes contains as many as 200 pairs of

contact between the two springs, S¹ S², which are normally apart. S¹ is attached to a movable piece, P¹, kept in the break-circuit position by a strong spring. The coin, C, drops between P¹ and another movable piece, P², actuated by the push-button, B. The coin when dropped rests in the first position and forms a bridge between P¹ and P². The thrust of the push-button brings S¹ and S² together, as shown in the second position, and the release allows the coin to drop into the till. The firm has devoted a good deal of attention and ingenuity to supplementing domestic bells, both mechanical and electric, by telephones, so that the servants may not

only be called but spoken to, and thus saved a journey of enquiry. Fig. 6 shows the device as applied to ordinary mechanical bell-pulls. The rosette is removed from the pull and replaced by an ebonite disc, which supports a magneto watch telephone in spring clips. A similar instrument is provided in the kitchen, and twin wires are run through the house, with branches to each bell-pull. This combination of the old and new certainly possesses the merits of cheapness and simplicity, and there is no reason why it should not work satisfactorily. The same idea is applied to an existing installation of electric bells, the telephone being carried on a clutch-plate and fixed to the wall alongside the usual push-button. In this case the electric bell wires serve likewise for the telephone.

AN EXAMPLE OF CHURCH LIGHTING.

A "dim religious light" may be poetic, it is certainly not pleasant. Modern worshippers, whatever their denomination, want to be able to see, and, may we add, be seen. To light a church or chapel brilliantly by means of gas means also introducing into that church or chapel the most certain cause of headache and *malaise*. It is necessary to light the gas some time before service. Occasionally this is done hours before in order to warm the church, the result being an atmosphere which quickly induces a "used-up" sensation. The building is a lethal chamber on a large scale, only needing to be hermetically sealed to produce fatal results. Clergymen who use gas in this way should not complain if a certain drowsiness is noticeable among the members of their congregation by the time the sermon is reached. Human nature cannot long hold out against the effects of asphyxiation even when the process is slow, and not commonly understood as such. Or take another point of view. As we have said, people want plenty of light nowadays. With gas this means the production of an enormous quantity of by-products—not usually known by this term—which promptly attack, and in a comparatively short space of time work havoc with the decoration of a church. Many thousands of pounds have been spent on the decoration of our cathedrals and churches which might almost as well have been thrown into the sea, for in close proximity to costly gilding and painting are

The Mediæval Court at the Palace fitted up as a Sanctuary—Messrs. Benham and Froud's exhibit.

long rows of gas jets emitting that which will effectually ruin both. By-and-by no doubt the beauties of our ecclesiastical architecture will be illuminated by nothing but the electric light, and people will wonder how a bygone generation could have been such lunatics as to employ gas. This movement in the right direction will, we hope, receive a stimulus from an example of church lighting and decoration to be found at the Exhibition. Here the energetic firm of **Messrs. Benham and Froud,** of Chandos-street, Charing Cross, in conjunction with **Messrs. Frank Smith and Sons,** of Southampton-street, Strand, have fitted up a sanctuary in a way which does them credit. Originally Messrs. Benham and Froud intended to erect a special stand for the purpose. It was suggested to them, however, by the Crystal Palace authorities that the Mediæval Court there provided them with just what they wanted ready to hand, and would give them a far better opportunity for carrying out their design than could be obtained by the erection of a stand howsoever cleverly constructed. The firm in question readily

adopted the suggestion, and the result is in every way satisfactory. In passing, we may remark that the various courts, representing different styles of architecture, are well worthy of a careful study on the part of visitors to the Exhibition. The plaster reproductions have been so well done as to almost deceive the eye, whilst the collection includes examples from some of the most noted buildings in this country and abroad. But to return to the Mediæval Court, which readers will find to the right of the Edison-Swan exhibit looking north. The sanctuary includes some very beautiful examples of church embroidery and metal work. The altar is furnished with six massive brass candlesticks and cross, with medallions of the four evangelists in oxidised silver. The embroidered dossal hangings and altar cloth have been supplied by Messrs. Frank Smith and Sons, and are handsome specimens of this class of ecclesiastical fittings. A brass eagle lectern of fine workmanship stands to the left of the altar steps. Lecterns of the same pattern have been supplied to Glasgow Cathedral, St. Stephen's, Westminster, and other churches. A specimen panel in patent metal mosaic, with the figure of St. Luke in hand repoussé work, should attract some attention. It is made by a new method of imitating ordinary mosaic in metals. Those employed in this case are copper, brass, and nickel, and the effect is very good. From the roof depends a very fine 12-light electric corona in brass, and also two other coronas in wrought iron. Two specimen standards carrying nine lights each, for use in a chancel, are also shown. The leads to these lights are run on a method introduced and fitted up by **Messrs. Smythe and Payne,** of Albany-buildings, Victoria-street. The system consists of concentric copper tubes insulated from each other and encased in fireproof material, the whole being sheathed in brass. This brass sheathing gives the leads an appearance in complete harmony with the ordinary church fittings, and they do not obtrude themselves on the eye. The *tout ensemble* of this exhibit is very fine, and we congratulate Messrs. Benham and Froud on the happy result of their efforts, which will, we think, cause many a dignitary of the Church to covet the electric light.

BUFFALO MEETING OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

The fifteenth annual meeting of the American National Electric Light Association was held at Buffalo on February 24. The abstracts of the papers just come to hand show that a large proportion of practical and interesting papers were read. Some of these dealt more particularly with American practice, but of the others the following abstract gives the principal points dealt with and the conclusions at which their authors arrived. The first, that on "Alternate-Current Motors," by Mr. Wm. Stanley, jun., being extremely important, we give in full elsewhere.

THE RELATION OF SIZE AND EFFICIENCY IN TRANSFORMERS.

A paper which comes very *apropos* at the present moment is that with the above title, by Mr. L. B. Stilwell. The designer of a transformer, says Mr. Stilwell, has two alternate paths: he may aim at high efficiency at light loads, or he may aim at large output with little weight, in which case he may endanger the insulation. The best transformer is not necessarily that which has the least loss in magnetising current, nor that which regulates most closely, nor that which is lightest, nor yet that which does not increase in temperature, but the one that best embodies all these properties. A commercial five-light transformer cannot be made to lose less than 20 watts, but a 10-light transformer can be made to lose not more than 25 watts. If the capacities are 250 and 500 watts, the losses are respectively 8 and 5 per cent. A 20-light transformer can be made with an iron loss of 30 watts, and for 40 lights at a loss of 45 watts—respectively a loss of 3 and 2·25 per cent. A 40-light transformer substituted for two 20-lighters will reduce the loss from 3 to 2·5 per cent., and more if substituted for smaller sizes. Transformers for 100 lights can be made with a loss which does not exceed 1·7 per cent., but beyond this size improvement is difficult. The loss due to copper resistance is usually about 2 per cent., not varying materially in the various sizes. Assuming the copper loss constant, the following table represents the average proportionality of losses. Actual tests show results as good as, or even better than this:

Capacity in 16-c.p. lamps.	Loss in iron.	Loss in copper.	Efficiency at full load.
5	8 per cent.	2 per cent.	90 per cent.
10	5 ,,	2 ,,	93 ,,
20	3 ,,	2 ,,	95 ,,
30	2·5 ,,	2 ,,	95·5 ,,
40	2·3 ,,	2 ,,	95·7 ,,
60	2·1 ,,	2 ,,	95·9 ,,
80	1·9 ,,	2 ,,	96·1 ,,
100	1·7 ,,	2 ,,	96·3 ,,
300	1·5 ,,	2 ,,	96·5 ,,

It will be seen that for sizes less than 20 lights the falling off in efficiency is very great, while above that the gain is less marked. The significance can be better realised in the following comparisons, expressing the losses in lamps and taking a total capacity of 1,200 lamps of 16 c.p.

Transformers.		Loss in lamps at no load.	Loss in lamps at full load.
240	5-light capacity	96	120
120	10 ,,	60	80
60	20 ,,	36	60
40	30 ,,	30	54
30	40 ,,	27·6	51·6
20	60 ,,	25·2	49·2
15	80 ,,	22·8	46·8
12	100 ,,	20·4	44·4
4	300 ,,	18	42

These figures show plainly that for any number of lamps up to 100 it is better to use one transformer rather than a number of smaller transformers; above 100 the gain is not so marked.

In the discussion, Mr. Wm. Stanley, jun., remarked that the most efficient transformer would be, he believed, the hottest—that is, build a coil and get in it as much iron as possible. Prof. Elihu Thomson thought a transformer would run best if the iron were run as hot and the copper as cool as possible. If the core were enclosed and the copper ventilated, we should obtain the ideal transformer. Mr. Stanley questioned if the transformer of the future would have inflammable material in it at all; he was making transformers with the copper embedded in a solid dielectric, the section resembling that of a well-constructed cable.

TRANSMISSION OF ELECTRIC ENERGY.

Mr. H. Ward Leonard read a paper on the "Transmission of Electric Energy by Alternating Currents, and its Utilisation by Continuous Currents." He made the claim that economical transmission of power over long distances necessitated the use of both alternate and continuous currents. The plant at the receiving end should be installed exactly as if to be driven by a steam engine, but should instead be coupled to a synchronous alternate-current motor, which should be started by a small storage battery or other means. If one comprehensive plant were installed, he believed an enormous development of this system would immediately take place.

HIGH-TENSION CURRENTS UNDERGROUND.

Mr. E. A. Leslie has an extremely practical paper on the underground conduits in New York for high-tension conductors. The "trunk" ducts are of iron pipe, mostly 3in. diameter, running to manholes 275ft. apart. Over the trunk ducts are two to four distributing ducts, with four-way manholes, 50ft. apart. The conduits are owned by the Subway Company. The companies Mr. Leslie is connected with use cables insulated with rubber compound. A copy of the specification is given of these cables. The manner of drawing in is explained. The proper jointing is regarded as a matter of paramount importance—unless made by an experienced man the joint shows nearly always less insulation than the cable. The following rule of the Subway Company, at one time impossible of compliance, is extolled by Mr. Leslie as the preventive of after-loss:

Section 4.—*Electromotive Force.*—All conductors drawn into and operated in the conduit, and intended to convey currents of an electromotive force exceeding 100 volts, shall have at the temperature of 75deg. F., an initial resistance of not less than 15 megohms per mile per 100 volts electromotive force of current in

the circuit. Whenever the resistance of a conductor, as aforesaid, shall prove to be less than five megohms per mile per 100 volts, the use of that conductor shall at once cease, unless the actual electromotive force in its circuit be so reduced as to re-establish the foregoing ratio.

This means that for a 1,000-volt circuit an insulation resistance before the current is turned on of 150 megohms per mile is required, and for 3,000 or 4,000 volts, 450 and 600 megohms. These seem difficult conditions, but it is rare that the tests on the New York cables do not show three to four times this resistance, and these have remained nearly, if not quite, as high for two or three years. Examples were given. Tests are made every week with a portable reflecting galvanometer. The insulation, including arc lamps or converters, usually falls below this standard, but unless less than one megohm per mile, the condition is accepted. Lower than this, lamp or converter tests are made and the defect removed. The cost of house connections is very high—appalling, to a man of overhead experience only. The cost of connections to city lamp-posts, including pipe, cable, and labour, is 110dols., say, £22, per post. Mr. Leslie goes into the financial aspect of the hire of subway ducts. The rental is 1,000dols. for distributing ducts, and 550dols. up to 900dols. for trunk ducts. The cost may be judged from the statement that the total rental of ducts exceeds the total for coal, oil, waste, and the salaries of chief engineer, engineers, firemen, coal handlers, and oilmen employed in the machinery department. He sums up the question thus: The underground system of lighting is perfectly possible on an extended scale; it is less liable to interruptions than the overhead system; it is less dangerous to life; its cost is enormously greater; it is very cumbersome, and lacks flexibility; and its cost precludes its extension to sparsely-populated districts, which must either be supplied by overhead wires or abandoned.

TRANSMISSION OF POWER FROM NIAGARA.

Mr. Carl Hering read a paper on the "Transmission of Power, with Special Reference to the Frankfort Plant." The paper first described the apparatus used on the Lauffen-Frankfort transmission, and gave a lucid explanation of the three-phase current. Mr. Hering closed his lecture with the following passage:

"The Oerlikon Company gives the following figures regarding the cost of the plant: Assuming the 300 h.p. is developed at Lauffen, and that all the energy received in Frankfort was converted into light, the cost of the plant per effective horse-power measured at the terminals of the lamp will be about £56, of which £47 is for the line alone. These figures appear high, but it must not be forgotten that in this particular plant there were conditions which would not be likely to occur in practice—namely, relatively small power on the one hand, and exceedingly great distance on the other, both of which factors naturally increase the cost per horse-power. It may be of interest to state that Mr. Dobrowolsky, of the Berlin firm, states that he would be willing to bid on the contract to transmit 1,000 h.p. or 5,000 h.p. from Niagara to Chicago, a distance of about 500 miles. He proposes to use 40,000 to 50,000 volts, and claims that an efficiency of 60 to 75 per cent. could be obtained without difficulty."

He also adds the following: "I received this morning a letter from the Zurich people, the Oerlikon Company, who you may know have put in a bid for the transmission of power from Niagara Falls to Buffalo. They propose that the current generated at the Falls is to be such that both motors and lamps—arc lamps as well as incandescent lamps—shall be used. That is, the current shall be fit for motors, arc and incandescent lamps. They say the Drehstrom—that is, the rotary current—is at present, and will be for a long time to come, the only practical form of current to run large motors of a fair efficiency. They propose to use 50 periods in place of 40, which were used at Lauffen, because they say that 40 is too low to run arc lamps. Fifty is said to be the lowest at which arc lamps will run satisfactorily. The generating station would be composed of units of 5,000 h.p. each. The dynamos must therefore be of 5,000 h.p. According to the wishes of the turbine *designers*, the number of revolutions has been fixed at 250 per minute. The diameter of the armatures has been fixed at 3½ metres—that is, about 10ft. The armature is to be drum wound. I suppose that means the drum winding on the surface of the cylinder—that is, not across the ends, as we usually wind drum armatures in America, but wound as they very often do in European multipolar machines. The currents are to be 2,000 amperes in each of the three circuits, and the voltage 600 to 700. It has been found advantageous to revolve the armature instead of the magnetic field, in order to have a minimum weight on the vertical shafts. The weight on one of those shafts, by the way, is something very great. The shafts are 20ft. long, and the weight of the shafts together with that of the armature and turbine is a very great weight, and must therefore be considered. The generators will have 24 poles. They will be separately excited. The efficiency will be in the neighbourhood of 96 per cent.—that is, the efficiency of the dynamo, including exciting power. There will be two transformers, as it was not found practical to build a single transformer of 5,000 h.p. The transformers will be artificially ventilated, and only the high-pressure coils will be placed in oil. These transformers will raise the potential to 25,000 volts. 'This,' they say, 'is no longer to be looked upon as an experiment. The cost of the line will be about 100,000f.—(that is, £4,000)—an almost trifling part of the whole for the total distance. It is a simple pair of copper wires—that is, three pair of copper wires on poles, the cheapest kind of a line. As to the line, we propose not to carry any more than one or two units of 5,000 h.p. on one line of poles for a number of reasons. A 5,000 h.p. or 10,000 h.p. can be conducted on wooden poles at a very moderate initial cost of plant. The lines would terminate in one or more step-down transformer stations that would supply current of 1,800 to 2,000 volts for municipal and street lighting in the shape of alternating currents to be transformed down to the suitable lampvoltage, as is the case in the present transformer systems. The cost of the electrical part of the proposed plant, including the generators, exciters, and transformers at both ends of the line, would be about 180,000dols. (£36,000) for each unit of 5,000 h.p. with an efficiency of 84 per cent. at the low-pressure terminals of the secondary transformers. This reduces to 36dols. (£7. 5s.) per horse-power. The cost of the line is about 4dols. (16s. 8d.) per horse-power, which is about 10 per cent. of the whole.'"

At the close of the lecture Mr. Hering showed a number of magic lantern slides illustrative of the Frankfort-Lauffen apparatus, line, exhibition, etc.

Prof. Elihu Thomson expressed himself in favour of the three-phase system, with underground wires in oil, which could be run up to 100,000 volts.

Mr. L. B. Stilwell preferred a two-phase system for combination work, where motors and lights were required.

Mr. C. S. Bradley spoke of his pioneer work in the rotary-current system, stating his preference for three-phase currents.

Mr. Stanley said it would be interesting to members to know that a 15,000-volt line was working at Pittsfield using 20 h.p. The striking distance is twice as great at this than at 10,000 volts. Within an inch or two of the ground there is a miniature aurora borealis, and the current will go right through a dry deal board without affecting the current in the slightest. They had undertaken a contract to transmit 400 h.p. a distance of 28 miles. The Dobrowolsky 2-h.p. motor, he was informed, required 4,200 watts to run at no load, and 14,000 watts (10 times its rated capacity) at full load. Of the current apparently applied, 14,000 watts, only 1,500 watts are actually useful. The Tesla motor uses ·6 of its full load current to run empty, and ·7 of this is usefully applied; so that about ·7 × ·6 × the total energy is required to run the motor. The synchronous motor has one serious defect, that if overloaded much it is liable to burn up.

BOILER FIRING.

"How to Fire a Boiler" was the title of a paper by Mr. R. Hammond. Amongst other things, he said: "Experiment has proved that bituminous coal requires 150 cubic feet of air per pound of coal for good consumption. An excess of air results in a waste of heat which is carried into

the flues and chimneys, and often a greater loss than the insufficiency of supply of air to produce good combustion.

"In my experience for steam plant boilers carrying 80lb. to 160lb. of steam, I find that at least 20lb. of bituminous coal should be burned per square foot of grate per hour, and the air spaces of the grates should not be less than 50 per cent. of the grate area; if the grate surface is so large that only 10lb. of coal is consumed, it would be more economical to reduce the grate surface and burn not less than 20lb. with good draught, thus securing a good combustion. The same weight of coal burned on a large grate would not be as economical, on account of the low temperature; the temperature of the furnaces should not be less than 3,500deg., and the ratio of the draught area through the tubes or flues should not be less than one-sixth nor more than one-fourth of the grate surface, and the proportion of the grate surface should be at least as 35 to 1. The steam users should see to it that all parts of their boilers and settings should be of equally as good proportions for strength and economy as their engines; employ good, intelligent firemen as well as engineers, and see that both produce good indicator cards." It was insisted that intelligent firemen should be engaged and well paid; this would result in a reduction in the pounds of coal per lamp lighted. Judge ARMSTRONG in the discussion suggested that a "bureau of firing" should be organised.

OVERHEAD CONSTRUCTION.

Mr. E. F. PECK, in a paper on overhead construction, dealt with the practical side of this problem—the building of wire-towers and the running of overhead circuits. Referring to the poles, he said his attention had been recently called to the Haskins process, which seems to be highly successful. This process consists in the placing of timber in an air-tight retort, and subjecting it to the heavy pressure of superheated air, which permeates the whole section, thereby accomplishing the same result as a charring process, without altering any of the chemical properties of the wood. Joints should be soldered on all electric light circuits. He had found that wrapping a joint with tinfoil and then covering with a good rubber tape make a good substitute for soldering, easily applied, for temporary work.

The report of the Committee on Underground Conduits and Wires was read, describing various American and English systems. It was agreed the experience has been too short to give a fair comparison of cost between aerial and underground conductors.

The Committee on Safe Wiring recommended that the rules should be amended by prohibiting inside conductors being laid in plaster or cement in a room where inflammable gases are used; that the lamp and socket be enclosed in a vapour-light globe; that interior conduits must not be made of any substance liable to be injured by plaster or cement.

The report of the World's Fair Committee was also read.

Papers were also read, entitled:

"Electric Lighting from a Financial Standpoint," by Mr. Erastus Wiman.

"Transmission of Power," a mathematical paper dealing with the transmission of power from the consumer's point of view.

"From the Tannery to the Dynamo," by Mr. Charles A. Schieren, being the natural history of a belt.

"Construction, Safety, and Operation of Switchboards," by Mr. M. C. Sullivan.

"Franchises for Quasi-Public Corporations," by Mr. Allen R. Foote.

"The Underground Construction of the Buffalo Railway Company," by Mr. J. B. Craven.

Electric Organ.—The Vicar of Meanwood Church, Leeds, has accepted the tender of Messrs. Abbott and Smith, of Bradford, for a new organ controlled electrically. The keyboard will be detachable, enabling the performer to play from any part of the church. The organ will contain 29 stops and 1,385 pipes, and will be blown by a hydraulic engine.

WALSALL ELECTRIC LIGHTING.

PARTICULARS OF REQUIREMENTS AND STATEMENT OF INFORMATION TO BE FURNISHED WITH TENDERS.

The area proposed to be supplied with the electric light is coloured pink upon the plan. The length of the respective streets comprised in such area is as follows:

				Feet.
Wolverhampton-street	A	to	B	1,600
Park-street	B	,,	C	948
Bradford street to Vicarage-place	C	,,	D	1,500
Vicarage-place to George-street	D	,,	E	946
George-street to High-street	E	,,	F	810
Digbeth and High-street	C	,,	G	1,053
Goodall-street	H	,,	I	653
Bridge-street (Upper)	I	,,	K	615
Bridge-street (Lower)	K	,,	N	427
Leicester-street	K	,,	L	330
Darwall street	L	,,	M	229
The Bridge	C	,,	N	138
The Bridge	M	,,	N	181
Total				9,430

It is suggested, with a view to economy, that the generating station may be placed at the gas works in Wolverhampton-street, which are the property of the Corporation, but the contractors are at liberty to suggest any other site that may appear to them to be more suitable, giving their reasons for so doing. A plant is required sufficient for the demands of 3,000 60-watt lamps wired, and regard should be given to the fact that power may also be required for small motors, and reasonable provision should be made for this and also for future extensions. The works comprised in the tender are to be divided into four sections as follows:

BUILDINGS.

Section I.—The buildings are not desired to be of a highly ornamental character, but must be plain and good in all respects. Plans and details of such buildings as may be necessary for boilers, engines, and dynamos must be supplied, room being left for an extension of plant in each section.

BOILERS AND ENGINES.

Section II.—Details of these are to be given and a guarantee as to evaporating power with the ordinary coal of the district. The canal company's water, which may be used, is not good. Full particulars of these to be supplied, and a guarantee of horse-power per stated amount of steam at average working load. State make, speed, and guaranteed insulation. State the amount of coal that will be used per electrical horse-power generating at quarter, half, and full load. Give full particulars of all instruments to be supplied, and what switching apparatus would be provided.

STORAGE.

Section III.—If storage is included give particulars as to make, maximum discharge, and capacity, and specify particulars, including the necessary arrangements for switching and regulating.

MAINS.

Section IV.—Supply full particulars of these, stating sectional area, how insulated and guaranteed insulation, resistance per mile when laid. Give particulars of proposed system of laying, also of joint and test boxes. Separate prices must be given in the tender for each section. The whole of the work to be carried out in accordance with the provisions of the Walsall electric lighting order of 1890, and to the satisfaction of the Council and their electrical engineer for the time being. A price must also be stated in the tender for running for six months after completion, contractors paying all expenses excepting fuel and water.

Cost of Carbons.—Mr. James Blake, managing director of the Fareham Electric Light Company, states that the cost of their arc lights last year, on a basis of 2,000 hours, did not amount to £2 per lamp for carbons, and the total cost of carbons and attendance did not exceed £2. 10s. per lamp.

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CONTENTS.

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IMPORTANT.

RE BRISTOL ELECTRIC LIGHTING ADVERTISEMENT.

After our advertisement pages had been printed we received certain corrections, which are to the following effect: line 8 read, "steam dynamos with *Willans engines*"; line 9 read, "*Lancashire* boilers"; line 14, after boilers, insert "*and boiler makers only will be permitted to tender*"; after 25th inst., line 19, insert "*on payment of £3 for each specification, which will be returned on receipt of a bona fide tender from parties entitled to tender.*"

OIL INSULATION.

The time of oil as an insulator is coming upon us. So much may be judged from the signs of the times. The use of oil, especially heavy rosin oil, on electrical work has been long advocated by us, and we have devoted many articles to the description of the process of running cables in oil brought prominently forward by the late Mr. David Brooks, the system now in the hands of Messrs. Johnson and Phillips. The demonstrations by Brooks have, no doubt, had their effect, but, practicable as he showed the use of oil insulation to be, the employment of it on any large commercial scale has hung fire. It has required the work of Ferranti and of Tesla to draw the attention of the world to the advantages of very high potentials, and in these cases the great advantages of oil insulation become apparent. Necessity is, we all know, the mother of invention; and when circumstances require a process to be discovered, man seeks, and always finds. Sometimes, however, he finds it too early, and no use can be made of his researches. This has been the case with oil insulation, for it appears the advantages of this method of insulating cables were perfectly well known, and methods for its use even patented, by one of the greatest and one of the most modest of our present electricians, Prof. Hughes, who already, in 1859—over thirty years ago—as stated in his paper given last week, had fully tested and recognised the advantages, not only of oil, but of rosin oil for insulating purposes. Many electrical engineers who had never before perhaps given the matter more than a moment's thought must have recognised, after witnessing Tesla's experiments with his high-tension transformers in oil and Prof. Hughes's simple but highly interesting experiments with faulty wires in a tube of oil, that the high insulating power, together with the absolute certainty and ease of repair of fault, will stand them in the greatest stead in the coming problems of high-tension current transmission. Mr. Ferranti has long recognised its value, and his junction and transformer boxes have been built, we believe, for some years to use oil. Brooks himself laid and worked telegraph cables in England many years ago, and several installations have since been fitted with oil-insulated cables—amongst others at Keswick. The statements and experiments of Prof. Hughes will, of course, turn the attention of cable manufacturers to the more extended use of oil, and many who have credited Brooks with absolute priority in this question will now feel free to use the system. It is doubtful, however, whether this matter of priority really affects the question very much after all, for a principle cannot itself be patented, and therefore anyone is to this extent at liberty to use oil—and rosin oil. The use

of oil has, however, its limitations and its regulations, and these must in practice be strictly complied with. Any patentable apparatus or methods may therefore to this extent still hold good. Even were this not the case, those who have tried and worked the method must necessarily be those who know most about it, and therefore we can see that the eulogy of oil by Prof. Hughes and by Mr. Tesla will redound to the advantage of the firm who have been pioneers in this system. The extended knowledge and recognition of the advantages of oil as an insulator cannot but cause its increased application in the future to high-tension conductors generally, and may materially aid in the solution of that most difficult problem, the thorough control of high-tension current. For such a consummation all the names which are associated with this important investigation will deserve the fullest credit—a great part of the credit, as in so many other electrical inventions, devolving upon the honoured name of Prof. Hughes.

ALTERNATE-CURRENT MOTORS.

One of the most interesting and suggestive papers we have seen recently is that by Mr. Wm. Stanley, jun., on "Alternate-Current Motors," read before the Buffalo meeting of the National Electric Light Association, which we give in full. Suggestive as it undoubtedly is, most of the statements made dealing with the manufacture of a practical alternate-current motor are of processes which "cannot be disclosed at present." The author seems to have obtained some very definite results, his idea being to produce a motor—a "condenser" motor—which will run on an ordinary alternate-current circuit. The field winding is connected in series with a condenser. The armature, though wound specially, is substantially the same as a continuous-current armature, but is surrounded with copper bands, whose function is to take oppositely-induced currents (the loss being small), these currents preventing any magnetising effect or loss by hysteresis. The motor uses currents differing in phase, but obtained from an ordinary alternate-current circuit. Mr. Stanley and Mr. Kelly have discovered an entirely novel and complete solution to the problem of splitting a current from a single transformer into two currents varying in phase to any degree desired. The method of doing this is to be published shortly. Tesla motors could then be run on any ordinary alternate-current circuit. "The Tesla motor for the past five years," says Mr. Stanley, "has been waiting for one thing only to develop it—a current splitter—and we have found it." English electrical engineers will be glad to learn this, and alternate-current supply companies will draw breath with relief. The system, besides the special winding of the armature, embodies the use of condensers, and the most serious question was to find a suitable condenser. Here, again, we must take Mr. Stanley on trust. He has tried glass, which breaks eventually even at 1,000 volts; vulcanite is unsuitable from the metal chips or other impurities always present. Messrs. Stanley and Kelly have succeeded in producing what they term "films" from ·003 to ·006 of an inch thick that withstand with certainty 1,000 to 3,000 volts; condensers made with these films do not heat, show no residual charge, are cheap to manufacture, and, it is believed, do not deteriorate. As before, the processes of manufacture cannot be disclosed at present. The condenser motors start at full torque, run to a definite speed, and behave like continuous-current motors under load. Self-induction is almost entirely eliminated, and the efficiency, though low (40 per cent.) for small motors, reaches 75 per cent. for 2 to 5 h.p. motors, and will be still higher for larger sizes. Mr. Stanley may well be congratulated on his investigation, fuller particulars of which will be awaited with great interest.

TAUNTON.

It is well known to most of our readers that all parliamentary action relating to electric light contemplates the possibility of the local authority doing the work itself, or at some period after the work has been done by others, taking it over as a going concern. The example of Taunton is perhaps not exactly analogous to the taking over of an installation from the concessionaire of a provisional order or license, but it is a case where a central station has been equipped and carried on by private enterprise, and where now the local authority is considering the advisability of taking it over. Our opinions as to the local authorities doing the work themselves are well known, and unfortunately, as some consider, are not accepted by the mass of the industry. We have always contended that the best way to carry out central station work is under the local authority, and not by private companies. The next best way is by means of a local company, and this generally finds favour. The local authority possesses great advantages, which should lead to diminution of initial cost and of cost of maintenance. Sanitary, water supply, and lighting matters are just those matters with which the local authority should deal, because each one affects the general welfare, and the aim should be to benefit everybody, and not contribute to the gain of individuals. At any rate, the fact remains that local action in electric lighting matters is contemplated. Taunton was, so to speak, the first town to really patronise electric lighting; it seems to be the first town to consider the taking over of a going concern. The mode of procedure will therefore be interesting to all who in the future have to follow in the same direction, hence we feel no hesitation in giving verbatim the report of the committee to be considered at the next Council meeting. It will be seen that the committee has been in communication with the Board of Trade, and has obtained from the borough surveyor an exhaustive estimate upon which to base conclusions.

Calcutta.—Sanction has been granted to the engineer's estimate for 11,553 rupees and 1,393 rupees for a proposed electric light station adjoining the Halliday-street pumping station at Calcutta.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

SWITCHES AND THE CHATHAM ACCIDENT.

SIR,—I was pleased to read your article on the Chatham accident. You are quite right; the high-tension current should never be led into the house, then there would be no necessity for a switch to cut it off. A high-tension switch cannot be made on a small scale to be safe, and if made large enough, and it must be double-pole, the cost would be a serious item in a small installation. As you say, many of the switches are bad—condemnably is scarcely the word; cut off the "con" and you are nearer to it. A high-tension switch should be built on broader lines: the contacts should be further apart, the opening of it so far that the arc cannot follow, and the handle more like a railway signalman's lever, only made of wood; a man could then pull off a 2,000-volt switch without fear of burning his hands. Designers of these switches should study the arrangement on the Thomson-Houston switchboard at the Crystal Palace.—Yours, etc., W.

SIEMENS CABLE TRANSFORMERS.

SIR,—As some mention has been made recently of the Siemens cable transformer in your journal, it may be of interest to know that on April 3, 1886, I patented (No. 175,242) in France, a similar transformer, consisting of a stranded iron rope surrounded with two separate windings of copper wire.

I should be obliged if you can find space for the insertion of this letter in your columns.—Yours, etc.,

Baden, March 7, 1892. C. E. L. BROWN.

ASSOCIATION OF MUNICIPAL ENGINEERS.

A meeting of the Incorporated Association of Municipal and County Engineers was held on Friday and Saturday last. A paper was read by Mr. William Weaver, M.I.C.E., on Saturday before the members meeting in the Kensington Town Hall dealing exhaustively with the vestry work of Kensington, from which we extract the following paragraphs dealing with electric lighting:

"The whole of Kensington is within the area supplied by the Gas Light and Coke Company, and the author gave details as to number of lamps and cost. With regard to the Electric Lighting Act, the author advised the Vestry to apply for a provisional order and go in for the work themselves, a course since adopted by the Vestry of St. Pancras. Looking to the enormous amount which would have to be raised, and the probable discontent of residents in districts outside the first areas lighted, the Vestry deemed it preferable to divide the parish into six areas, which have been allotted to five companies—viz.: London Electric Supply Corporation, Limited; Notting Hill Electric Lighting Company, Limited; Kensington and Knightsbridge Electric Lighting Company, Limited; Chelse Electricity Supply Company, Limited; and the House-to-House Electric Light Supply Company, Limited. The last-mentioned company undertakes the lighting of two areas. The system of supply adopted by the whole of the companies (except the House-to-House Company) is arranged on the low-tension system. The House-to-House Company's system is an alternating-current, transformer high-pressure supply, with high-pressure service lines from distributing mains, and transformers on consumers' premises, reducing the current to low tension. The provisional order granted to this company contains a condition, that so soon as the amount of supply in the district appears to warrant it, the company may be called upon by the Board of Trade to establish distributing stations and lay distributing mains worked at a low pressure. About 15 miles of roads and footpaths have been opened up for the purpose of laying electric mains in the parish. In some cases the conductors have been laid in brick or concrete culverts; in other places, *Callender bitumen tubes* or iron pipes have been used. In laying the mains numerous difficulties have to be surmounted—in fact, in some streets it has been a matter of extreme difficulty to find space in which to lay the mains. The author is strongly of opinion that all main roads, at any rate, should have a subway for the reception of mains, etc. If such subway was built simultaneously with the construction or reconstruction of the sewer, the additional cost would not be great; there would be no extra excavation, the additional cost would be for the brickwork only, plus the necessitated extra surplus earth to remove, and if the excavation was in sand, such surplus earth would form a credit. Stoneware pipes for the reception of the gas and water services and electric wires could be laid from subway to vaults, and if these pipes were laid in the drain trenches, the cost of the stoneware pipes would be the only extra cost beyond subway. The author is of opinion that if the cost of such subway works were defrayed by a loan spread over 50 years, the various companies could be charged a rent which it would be economical for them to pay, and sufficient to return a profit on the outlay. At the same time the appearance of the roads and footpaths would be vastly improved, and the comfort and safety of the public enhanced."

"The question of destructor or no destructor was made an election test, and by a considerable majority the proposal to erect a destructor was condemned, and subsequently the utilisation scheme adopted. The author's reports to the Vestry were in favour of the erection of a destructor for consuming the non-saleable part of the house refuse, and the employment of the waste heat in working machinery: first, for the washing of the refuse from flint and macadam roads; and secondly, for the generation of electricity. The electric current generated could be used for street lighting or for propelling the dust-carts. The latter would effect a saving of about a moiety of the manual labour now employed, and would of course abolish the horses now employed chiefly in standing about with their nose-bags on to keep them quiet."

VISITS.

The first visit of the association was on Friday evening to the Crystal Palace Electrical Exhibition, and in order to keep all the visits under one head we refer to it here. The members began their inspection of the Exhibition about 5.30, in two sections, under the guidance of Mr. Crompton's engineer and Mr. H. Swan, assistant editor of the *Electrical Engineer*. A visit was first paid to the Machinery Department, where the large central station plant of Messrs. Crompton, on the low-tension system with accumulators, was inspected. The high-tension alternating-current system of the Brush Electrical Company was next visited, and the working of the large Mordey alternator driven by rope gearing as used at the Bath and City of London stations, was watched with great interest. Messrs. Siemens's large direct-current low-tension plant, as used at the Naval Exhibition, and destined for the new station of the St. James's Company, came in for a share of admiration, though not running. Messrs. Davey-Paxman's engine, driving the large Kapp dynamo constructed by Messrs. Johnson and Phillips, was regarded as another excellent example of central station work; and the permanent engine and dynamos of the Gulcher Company, which light the Palace itself, was also visited. The motor-transformers, as used by Messrs. J. E. H. Gordon and Co., for supplying current from the Sydenham station to the exhibitors, was also inspected. A great deal of interest was manifested in the gas engines, especially those of Crossley, Wells, and the Stockport Company. An exhibit which all wished to see was the high-tension experiments of Messrs. Siemens Bros. Here illustrations were shown of the behaviour of direct and alternating currents, and the musical notes of the alternating current were heard in a telephone; but the most interest was aroused when the 50,000-volt current was turned on in an overpowering, spluttering, and creeping shower of lightning flashes over a 2ft. sheet of glass. The strength of the current was illustrated by lighting a row of 500 lamps in series arranged upon a single wire. Music from Manchester and the Lyric Theatre was next indulged in at the Telephone-room, and the huge screen of Edison-Swan lamps was seen alight. The illuminated waterfall and the kiosks full of lighted

lamps were most fairylike in their effect; the flashing of Crompton's projector illustrated the search light; and the Crompton crane, lifting, travelling, and slewing at the same time, was witnessed with much interest. The Brush Company's sets of combined engines and dynamos came in for much admiration, and their quartz-crushing machine was seen in operation. The Siemens passenger and dinner lifts were inspected, and then the visitors wandered through the electrically-lighted furnished rooms in the gallery—exhibited by Messrs. Wallace, Allen and Manooch, Godfrey Giles, H. and J. Cooper, Rashleigh Phipps and Dawson, and Messrs. Faraday and Sons.

The members on Saturday visited, among other places of interest, the West Brompton electric lighting station of the House-to-House Electric Supply Company. Much interest was taken in electric plant at this meeting from the pressing importance of the subject. Mr. Hammond received the visitors personally, and explained the system used, of slow-moving engines driving alternators, adopted as a standard type of central station, and employed at Dublin and Madrid. The working of the alternating dynamos and the switching apparatus was explained, and attention was drawn to the fact that one dynamo had run 665¾ hours continuously without breakdown.

The last visit of the day was to the Kensington and Knightsbridge electric lighting station, a visit which was greatly appreciated both from the interest of the station itself and the courtesy of the company's engineer, who very clearly explained the working. They had, he said, a number of Willans engines coupled direct to Crompton dynamos; these could be started at a few minutes' notice to supply the current. The low-tension current was used on the three-wire system, with accumulators. The switching was done upon a large regulating switchboard upon indication of pressure on the voltmeters connected to wires from the distant points. The accumulator-room contained two sets of large lead-plate accumulators, Crompton-Howell system, each set sufficient to supply 3,000 lamps for an hour. Two further sets were placed in a sub-station at some distance. The cost of manufacture was about 3d. to 3½d. per unit, which with general charges amounted to 5d. or 5½d. The price charged was 8d. per unit, and they sold all but 10 per cent. of that they manufactured. Lamps could be supplied within a radius of 1½ miles on this system without sub-stations. There was no danger whatever at any part of the circuit. The members afterwards dined together at the Holborn Restaurant.

THE BEHAVIOUR OF INSULATING MATERIALS UNDER THE ACTION OF HIGH-POTENTIAL DIFFERENCES.*

BY H. BLECKLY BOURNE AND W. FOX BOURNE.

Electrical engineers have recently been devoting a great deal of attention to the transmission of energy by small currents at high pressures; and it is clearly advantageous to increase the potential difference until the expense of insulating the apparatus neutralises the saving in copper. The question of insulation is, of course, the main difficulty, for as we increase the potential difference many substances, which are ordinarily considered insulators, have to be regarded as fairly good conductors. Numerous experiments were shown to illustrate this point, the current being obtained from a Hedgehog transformer, capable of developing about .25 h.p. at 100,000 volts, which had been lent for the occasion by Messrs. Swinburne and Co.

The question of sparking distance in air does not seem to be of any great practical importance, but as it has recently been referred to, the following figures, obtained at Messrs. Swinburne's works, may be of interest:

Sparking Distances Between Needle Points.

P.D. in volts.	Sparking distance in inches
3,000	0·11
14,900	0·5
24,000	1·0
39,000	1·6
50,000	2·2
62,000	2·8
74,000	3·5
92,000	4·5
97,000	5·0

Sparking Distances Between Plates 2¼in. Diameter.

P.D. in volts.	Sparking distance in inches
13,000	0·16
20,000	0·40
44,000	1·0
70,000	2·0
90,000	3·0
105,000	4·0

The above results were obtained on a cold, dry day, but can only be regarded as approximate, as the distance was found to vary a good deal with atmospheric and other conditions, so that concordant results could not always be obtained on different days. By striking an arc between electrodes of tin wire, which gradually melted, a flame of considerable length was exhibited, and it was pointed out that the length to which an arc could be drawn depended very largely on the current strength available.

It was next shown that for overhead work at very high pressures even oil insulators of the best design are quite useless. Wires from the transformer were connected to the stalk and groove of an insulator which had been dried and filled with clean rosin oil; brush discharges immediately occurred over the surface of the porcelain, and when a P.D. of 60,000 volts was reached a spark jumped from the wire to the stalk. Two wires were placed near the ends of a piece of slate about a yard long, and sparks passed freely from the wires to the slate, and a sort of arc lamp was arranged with slate pencils for electrodes. A similar conducting power was shown to be possessed by vulcanised fibre and asbestos millboard. The discharge does not break down or perforate these substances; they behave exactly like conductors. A curious effect was shown with a long piece of slightly damp wood, numerous small arcs being formed, which finally ignited the wood.

The experiment with the oil insulator, and other experiments shown, point to the fact that surfaces of insulating materials, unless absolutely clean and dry, have considerable conducting power. A discharge may sometimes take place on the surface of a non-conductor across a distance much greater than the striking distance in air, and once a discharge has started an arc is formed. A cable insulated with a layer of rubber a foot thick might be useless for 50 or 100,000 volts, if it had even a small crack. This creeping discharge was also shown by the now familiar experiment in which a pair of discs are separated by a large sheet of glass. In one of the experiments shown the glass did not break, though the discharge passed through it, and it was found that if there ever had been a perforation the heat of the arc had fused the glass and entirely sealed up the hole.

The potential difference required to break down or perforate insulators is quite a different matter from the discharge over their surfaces. A number of samples of broken-down insulators were exhibited. They were materials which had been tried for use in condensers, and were in the form of thin sheets of mica, celluloid paper impregnated with various resins and waxes, etc., and were about six mils thick; they had been perforated with potential differences varying from 2,000 to 6,000 volts. A piece of cable insulated with a layer of vulcanised rubber of the best quality, rather over ½in. thick, was shown: it had withstood 50,000 volts for 25 minutes. In such cases the time element is of great importance, and the dielectric is usually found to become very hot before it breaks down. This fact indicates a very important difference between the effects of direct and alternating currents on insulators. Whenever, as in the case of a concentric cable, the two conductors are at all close together, we have a condenser which is being rapidly charged and discharged. Now in the case of most solid dielectrics there is a good deal of soaking in, and consequent loss of energy, which manifests itself as heat. This was made very evident in the case of a condenser which was tried at Messrs. Swinburne's works. This condenser was made of sheets of tinfoil insulated with paper soaked in paraffin wax in the usual way; its insulation, measured with a steady E.M.F. of 240 volts, was about six megohms, and

* Abstract of paper read before the Old Students' Association of the City and Guilds of London Institute, at the Central Institution, South Kensington, on March 11.

the active surface of plates was 5,000 square inches. When it was connected across a 2,000-volt circuit, it was found to absorb more than a horse-power, so that a considerable rise of temperature was not surprising. But it was also noticed that its capacity rapidly diminished, and finally disappeared, which was, on investigation, found to be owing to the fact that the foil had melted and so become disconnected from the circuit. Another condenser, made with glass plates $\frac{1}{16}$in. thick, broke down with 2,000 volts after about five minutes, apparently owing to internal cracks caused by the heat evolved. In the case of the sample of rubber-covered wire above referred to, the compound in which the braiding had been soaked, melted in five minutes, and the rubber became quite softened by the heat in about 15 minutes.

This heating effect is much less in the case of most fluid insulators, but seems to be more important in oils having a high specific induction capacity.

Some experiments were then arranged to show some actions of oils under high voltages. A plate was immersed in castor oil, and a point supported a short distance above the surface. On switching on the transformer a distinct depression was produced on the surface of the liquid. Two plates were then arranged, one over the other, separated by a layer of castor oil on which was floated some paraffin. When the plates had a difference of potential of 20,000 or 30,000 volts, the castor oil rose in a sort of hill, owing to the fact that its specific inductive capacity is higher than that of paraffin, so that by its movement the capacity of the arrangement is increased. It was also shown that particles of sawdust in rosin oil were formed into chains, producing a discharge across a considerable distance.

The experiments were concluded by sending the current from the transformer through a number of vacuum tubes. These were, of course, brilliantly illuminated, but the current was not maintained for more than a few seconds, as an intense heating of the glass and electrodes ensues, which usually breaks the tubes. This fact renders it difficult to measure the power absorbed, but it was estimated, from the primary current and voltage, that a comparatively small tube may easily be made to absorb about 2·5 h.p. while giving a light of only a few candle-power.

In the above-described experiments the potential differences were measured by a direct-reading electrometer, kindly lent by Messrs. Swinburne and Co. This and the transformer are intended to be used for experiments to be shown by that firm at the Crystal Palace Exhibition.

ALTERNATE-CURRENT MOTORS.*

BY WILLIAM STANLEY, JUN.

It is not my purpose in the present paper to enter minutely into the details of the various attempts that inventors have made to produce an operative motor. The historian who shall collect the data necessary to trace the rise and growth of the alternating-current motor will find that the subject has been pursued by men of science in all parts of the civilised world, and he will be obliged to chronicle the fact that up to the present year no thoroughly practical motor system has been worked out. The various plans suggested by inventors and by engineers may be classified into three types. They are: First, motors operating in synchronism with the current alternations, having a field magnetisation produced by continuous currents with alternate currents applied to the armature circuits, a type originally demonstrated by Hopkinson in 1883; second, motors actuated by the inductive effects of a rotating field upon closed armature circuits, first suggested by Mr. Tesla in 1887; and third, motors operated by alternate currents, in both field and armature, constituting one of the types investigated by Mr. Kelly and myself As far as I know, the first work on alternate-current motors in this country was undertaken at Great Barrington, 1886 and 1887, when I designed and built a synchronous motor, and a motor acting under the repulsive currents obtained by periodically short-circuiting armature coils while they were under induction from the field. One of these motors was designed in January, 1886. Prof. Thomson, in 1887 and 1888, also produced motors of this type, and, what was of still more importance, he read a paper before the Institute of Engineers memorable for the clearness with which he treated the subject.

In order to more clearly explain the troubles found in designing these and other alternating-current motors, I wish to call your attention to two of the properties possessed by circuits traversed by alternate or variable currents. When dealing with continuous currents we are accustomed to consider that the resistance of a circuit is determined by the area and length of the conductor, and by the specific material composing it. In dealing with alternate currents, it is desirable to extend the definition of the term "resistance" to a fuller meaning. The term "resistance," as you all know, is that property of a circuit which determines the amount of electrical energy disappearing per unit of current, the value of this property or "resistance" being obtained when the energy in circuit is divided by the square of the volume of current flow.

When steady currents occupy a circuit, the resistance value is confined to the conditions which exist within the conductor—viz.: the "resistance" is proportional to the length of the circuit, inversely proportional to its area, and dependent upon the kind of material employed. When variable or alternate currents are applied to a circuit, the resistance proper may not be confined to the interior of the conductor, but may extend to its surrounding neighbourhood, for with these changing currents work may be done outside of the conductor as well as inside of it, and, as the losses by hysteresis and by induced currents cause a disappearance of electrical energy, they may be defined in terms of the current flowing and a resistance factor. When alternate currents are used, this factor is always greater than when steady currents flow, and while in particular cases the disappearance of electrical energy taking place outside of a conductor may be small, there are cases in which the energy lost outside far exceeds the loss within the wire itself. Another point may be noticed We are accustomed to think of the resistance of a wire as a fixed quantity; we say a circuit has 10 ohms resistance, and we are in the habit of thinking that this value of 10 ohms is approximately constant and independent of the current flow. While this supposition is true for steady currents, it is not true for those of changing value. If the conductor carrying an alternate current is of small section less than $\frac{1}{4}$in. diameter, the internal resistance of the circuit remains nearly constant for alternate currents of the frequency we are accustomed to handle, while the external resistance, if I may be allowed to use such a term, increases with an increase of current and may increase as the square of the current, or faster. While I am aware that this treatment of the term "resistance" is not in ordinary use, yet it is quite orthodox; it has been defined by the mathematicians, and its use may be justified, as it is often instructive in comparing the losses taking place within and about a conductor occasioned by the flow of alternate currents. In designing alternate-current motors, for instance, the loss of energy exterior to the circuits has to be very carefully watched; for example, an alternating-motor armature wound in the ordinary manner might carry one ampere of current with very little loss other than that due to its interior or ohmic resistance, while 10 amperes might cause a loss exterior to the wire by hysteresis and eddy currents several times the ohmic loss in value, or the exterior resistance might become so great as to practically prevent the flow of current to the value desired.

The other property of a circuit carrying an alternate current to which I wish to allude is its so-called inductance, which is the property of inducing upon itself an E.M.F. The E.M.F. thus produced combines with the other E.M.F.'s in circuit to determine the direction and value of the current at any time. It is not necessary for the purposes of this paper to trace out just why or how it happens that these E.M.F.'s are developed, or why they do not coincide in phase. By looking at the printed sheet, Fig. 1, you will find the diagrams which illustrate the phase differences of these E.M.F.'s; that marked I. is the E.M.F. in a circuit which urges the current against the resistance of the circuit whether the resistance be within or about, or both within and about, the conductor. The curve marked II. indicates the relative position or phase—that is, time of flow of the E.M.F. of self induction—which, as you see, is to the right of the first E.M.F., and, lastly, you will find the phase of E.M.F. developed upon a condenser when attached to a source of alternate currents.

For the present it is only necessary to notice that two of these E.M.F.'s, II. and III., have their maximum and all corresponding values at the same time, as, for instance, at the time, C, II. and III. are opposed in direction, A being + direction, B being − direction, while the maximum value of each falls upon the same time line.

Let us now briefly examine the various types of motors that have been suggested, and which I have classified in three types.

It is well known that if an alternating dynamo be run until its speed of alternation or frequency is approximately the same as that of the generator from which it is to be supplied, and if its field is properly magnetised, it can be coupled to the generator by simply closing a switch; it will then fall into step with the generator, and will take load and behave in a very proper manner; the trouble is to get it into step without employing costly or complicated appliances. If one attempts to start such a machine by commutating the current in the ordinary manner, he will find that the current will refuse to flow in the field circuit, the inductance of the circuit keeping most all the current out. How to start a synchronous motor is a problem still unsolved, but Mr. Kelly and myself believe that we have found a solution.

It is not to be understood that all dynamos will run as synchronous motors with equal satisfaction, for while the machines made in this country will so run, they are not to be compared for this or multiple connected service with the Mordey machines made in England, which, by the way, I consider to be the best-designed alternators yet produced. The reason why the Mordey machines excel as synchronous motors is, that the inductance or self-induction of the armature circuit is so low that the slightest tendency to fall out of step is instantly corrected by the necessary current flowing in the armature.

If one attempt to couple two or more of our American alternators in parallel (I refer to surface-wound machines), he will find that a large false or useless current will surge to and fro

* Paper read before the meeting of the National Electric Light Association, at Buffalo, Feb. 23, 1892.

between the armature circuits; this false current is due to the fact that when two alternators are put in parallel there are always short intervals of time, during which one machine leads and does work upon the other. This interchange of current between the machines tends to bring them into more perfect step. Mr. Mordey's machines may be said to be always alert to correct any difference of phase—in fact, they may be imagined to correct each other at the first intimation of the lagging machine, while the American machines allow the laggard to fall a considerable distance behind before the necessary correcting current passes.

While many inventors were eagerly following their various lines of investigation for the purpose of producing an operative motor, Mr. Tesla had quietly worked out a new solution of the problem on an entirely novel basis, by inventing the rotating field—that is, the field produced by shifting magnetism, and producing it by alternate currents. Mr. Tesla's motor is so simple and so beautiful in theory that many have doubtless wondered why it has not been brought into general use. If I correctly understand the subject, it has not been commercially adopted because of the difficulties in operating it at the frequency generally in use in this country—viz., 130 complete periods p. s.—and especially because thus far special generators and circuits having phase-differing currents must be employed. There have been many attempts to subdivide alternating currents into two or more currents differing in phase. Special arrangements of condensers for producing phase differences from a single source of supply have been worked out by M. Leblanc in France, and by Mr. Kelly in this country. As regards the motor itself, there are two drawbacks to its use which have not thus far been entirely removed. They result from the inductive effects of the currents upon themselves and upon each other.

To understand this matter in a practical sense, let us assume a Tesla motor having 300lb. of iron in its field and armature to be magnetised. Suppose it to be supplied with a 16,000 alternate current at 300 volts pressure. We have 300 volts then applied to each of the two field circuits. We can count on the motor being magnetised to at least 20,000 C.G.S. lines per square inch of iron, which, with a loss of one watt per pound in hysteresis, would then represent an external resistance loss, that is, a loss outside the wire, of 300 watts, and a resistance of $\frac{300 \text{ watts}}{C^2}$. In this case the internal resistance of the copper coils may be made low and may be neglected.

Now, it is evident that the magnetisation produced in the field will react upon the field coils and will develop an E.M.F. of self-induction, and this E.M.F., as shown in Fig. 1, will be 90deg., or half a semi-period from the E.M.F. urging the current against the resistance; let the value of this induced E.M.F. be 250 volts, then the E.M.F. urging the current against the resistance will be found by

$$\sqrt{(\text{applied E.M.F})^2 - (\text{E.M.F. of self-induction})^2} \text{ or } \sqrt{300^2 - 250}$$
$$= 165 \text{ volts.}$$

That is to say that of the 300 volts applied, 165 volts are used up in urging current to magnetise the motor when it is doing no work, and 250 volts are available for inducing currents in the armature. If, as we have assumed, the loss due to hysteresis is 300 watts, then the current flowing would be $\frac{300 \text{ watts}}{165 \text{ volts}} = 1 \cdot 8$ amperes, and the resistance external to the wire $\frac{300}{(1 \cdot 8)} = 92$ ohms.

I do not mean to say that these conditions are actual or cannot be improved; they ought to be. I present them simply to show that with this type of motor the full E.M.F. employed is not available, as in the example, when with 300 volts applied, but 250 volts are available and 165 volts are lost.

Moreover, it is necessary that a strong field magnetisation should be developed in a motor in order that a powerful starting torque may be had; as a consequence, the field circuits of this motor must be composed of a comparatively small number of turns of wire (the flux or magnetisation in an alternating magnet being inversely as the number of turns with a given applied E.M.F. and with a magnetic circuit of given reluctance). It might also be shown that the value of the field producing current in these motors—viz., the current required to run the motor empty—is largely dependent upon the air gap between the field and armature, the current at no load being greater as the clearance between the field and armature is increased. The Tesla motor then must necessarily have a false or lagging current at no load, and must expend considerable energy in the production of the rotary field by hysteresis loss, until someone, and Mr. Tesla as likely as anyone, shall find an iron without hysteresis and an air gap that does not require magnetomotive force. I understand that these motors require about ·6 of the full load current when running free with a factor of lag of about ·7, so that the actual percentage of energy required to run them free is, approximately, ·6 × ·7 = 42, or, say, 40 per cent. of their full load energy. This is a rather serious matter when viewed from the standpoint of the station manager, for if the motor service requires ·6 of its full load current to run free of work, then evidently ·6 of the station capacity must always be in operation. There is another slight trouble with these motors, resulting from the fact that the coefficient of mutual induction does not keep up as the motor is loaded. This may be explained by saying that the flux, and consequently the E.M.F. developed in the short-circuited armature coils, decreases as the motor is loaded; this decrease of induction affects the speed of the motor, causing it to fall off with load, while it requires a larger current in the field to furnish an increased amount of work. Both of these difficulties, however, are very largely determined by the design and calculation of the motor itself, and may be brought within working limits. I see no reason why this motor may not be made successful and operative by proper designing and careful study.

The problem before those studying the alternate-current motor is, however, entirely independent of these difficulties. Had we a reliable means of dividing an alternate current into two currents having the proper difference of phase, Mr. Tesla's motor would be made available and would be of great commercial value. Mr. Kelly and myself have found an entirely novel and complete solution to the problem. As far as we can discover it has never been attempted by any other experimenters. By the use of a very simple invention we are able to draw from a single transformer secondary two phase-differing currents, having any differences of phase we elect. These currents maintain their phases—that is to say, times of flow—independent of the amperage of the current and of each other. We can apply our invention at the station, splitting the primary current from the dynamos into two phase-differing currents, or we can lead the primary current through a transformer and split the secondary into two components.

I regret that I am unable to disclose the methods we adopt, but I hope to be able to publish our results shortly. Our method will then allow us to run the Tesla motors from the same circuits, and by the same generators that we now employ in incandescent alternate-current lighting. The Tesla motor for the past five years has been waiting for one thing only to develop it—viz., a current splitter, and we have found one.

Mr. Kelly and I have invented what we call a "condenser motor," which differs radically from either of the above-mentioned types. The problem which we have had in mind was to construct a motor which should be operated by existing alternate currents in exactly the same manner that we operate an ordinary motor when supplied with continuous currents. To do this, it is necessary to construct a motor whose circuits do not possess (effective) self-induction, or, to put it another way, it is necessary to take away from the alternate-current circuits the effects of the E.M.F.'s induced in them by their own currents, which renders unavailable a considerable part of the E.M.F. applied.

I will attempt to explain our shunt motor without the use of formulæ, illustrating the results obtained as best I can.

Our motor has a laminated sheet-iron field, and may be made in any of the multipolar or bipolar types. The field winding is connected in series with a condenser to the secondary of a transformer, which, when fed from the station, furnishes the source of supply. The armature of the motor, although wound with a special winding, is substantially the same as a continuous-current armature, and is surrounded by closed copper bands whose function I will describe later. The theory of the motor is, that, given the necessary magnetisation and armature current, the motor will operate as well with alternate as with continuous currents. Returning to the field circuit, let us glance at the function of the condenser. If the field windings were connected directly to the transformer or source of supply we should have two E.M.F.'s in circuit, combining to oppose the E.M.F. applied by the transformer. Let the line A-B, Fig. 3, be this E.M.F., and let B-C be an E.M.F. whose value is found by multiplying the current (in the case assumed) by the resistance of the circuit. By resistance is meant the internal or ohmic resistance plus the external resistance due to hysteresis and eddy currents, then A-C is the E.M.F. of self-induction; the two E.M.F.'s, A-C and B-C, combine to always just balance the transformer E.M.F.

Now, in any operative type of motor the E.M.F. A-C will always be greater than B-C, or simply the opposition of A-C will be so great as to practically obstruct a flow of current in the field. If, now, we could introduce a third E.M.F., such as C-D, which should always oppose A-C, we could neutralise the effect of A-C upon the time of flow and value of the current, which in that case would not be opposed by any E.M.F., except C, R, or $C = \frac{E}{R}$, as in the case with steady currents.

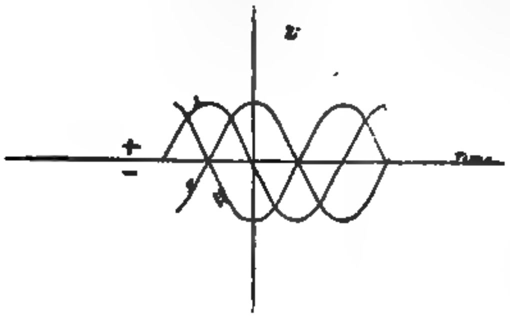
To get this third E.M.F. we insert a condenser whose capacity is so chosen that the field current will develop a potential upon the condenser terminals equal to the E.M.F. A-C; if the field current changes in value from time to time, it will change the values of both A-C and C-D (as these E.M.F.'s are in series connections) in almost the same ratio, and consequently these two E.M.F.'s, the one on the condenser and the other on the field coil, will always neutralise each other's effects, and the circuit will be left free to the current flow, as with continuous currents. Perhaps this may be made simpler by considering the resultant effects produced by a number of alternators coupled in series, Fig. 4. Let A, B, and C be these generators; let them be all rigidly coupled to the same shaft, A being set on the shaft so that its armature generates an E.M.F. 90deg. away from that of B and C, while B and C are coupled to produce the same voltage at the same time and have their terminals opposed; then B and C will exert no effect upon the circuit, for they will always neutralise each other. The E.M.F. of A corresponds to the transformer E.M.F.; the E.M.F. of B to the E.M.F. of self-induction on the field coil, and the E.M.F. of C to the E.M.F. on the condenser. In this way we obtain the necessary current to magnetise our motor unrestrained by the E.M.F. of self-induction.

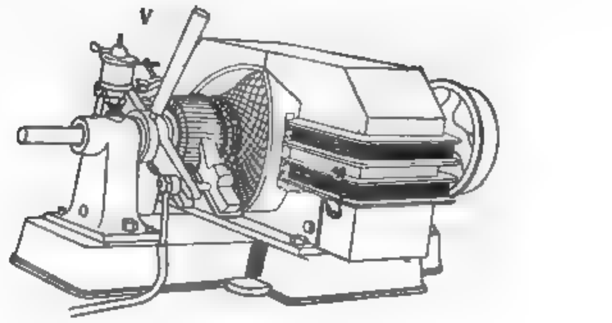
The next difficulty to clear up in order to operate our motor, is to get rid of the external resistance in the armature circuit. In order that a motor may operate economically and regulate properly for changes of load and current, it is desirable that the armature resistance should be very low. The principal resistance offered to alternate currents in an armature is, as before stated, due to the work outside of the armature wire in the iron core; these losses in the iron are occasioned by the alternating magnetisation developed by the armature current. To remove this loss of energy

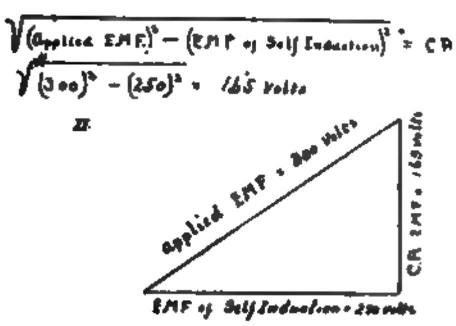
we have had to destroy most all of the armature magnetism in the following manner:

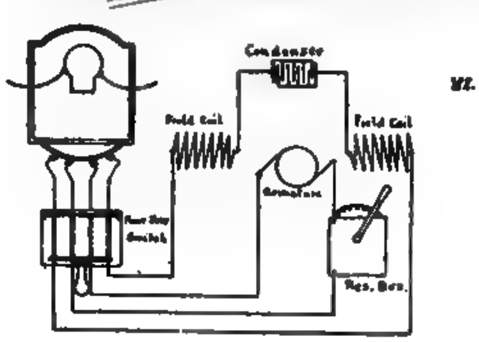
You are all aware that if a magnet core is wound with two equal coils in opposite directions and is connected with a current source, the resulting magnetism will be only that due to the difference of the winding displacement, and will be practically negligible. About our armature, see Fig. 5, we place close-circuited copper bands or wires, so disposed as to be parallel to the direction of current flow in the armature conductors. The currents flowing in the armature windings induce oppositely directed currents in the stationary bands, and, consequently, the armature core is surrounded by two sheets of current during each wave of current flow; the sheet of current on the armature flowing in one direction, while the current in the stationary bands flows in the opposite direction, thus practically preventing any magnetising effect, and thus, also, preventing any loss by hysteresis and eddy currents in tinuous-current motor. It is not to be understood that the motor has an efficiency of 96 to 98 per cent. Far from it. In our small motors (½ h.p. and ¼ h.p) the losses in the field and armature will aggregate 30 to 40 per cent. In the larger types of from 2 h.p. to 5 h.p. the loss will not exceed 25 per cent., while in the still larger sizes the losses will be much less. The problem of the efficiency of the motor is almost the same as the efficiency of the transformer, and depends in large measure on the care and skill of design.

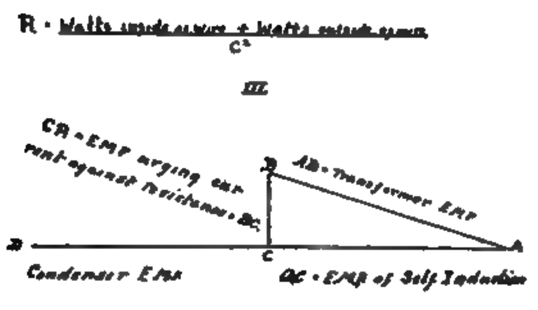
To operate our motors it is necessary that the speed of the dynamo should remain constant—as constant as possible. If the stations will give us a definite number of alternations, and will maintain that number, our motors will behave beautifully; if the alternations change, the condenser E.M.F. will no longer exactly oppose the lagging E.M.F. of self-induction and the field current will change and lag either positively or negatively. Mere change of E.M.F.

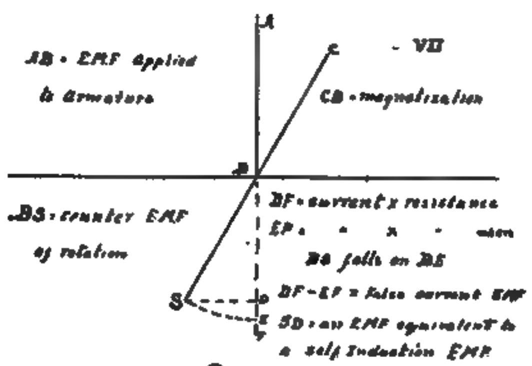


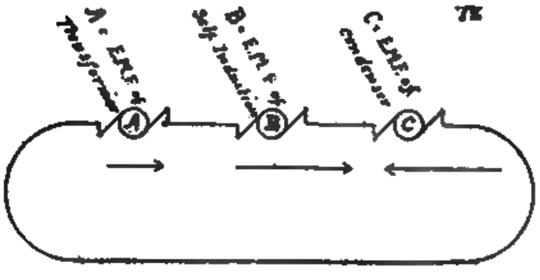


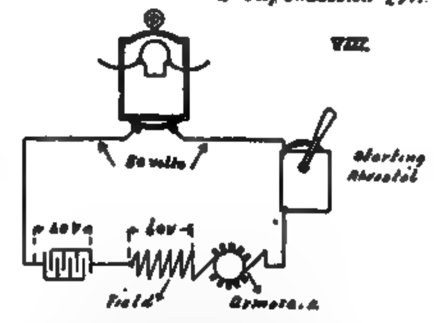












the core. Now, it can be shown that the work lost in the copper bands will be very small, providing the resistance of these bands be kept low, and we have found that this loss can be made as low as one-third of the inside or ohmic loss, a result which enables us, by proper designing, to make our armatures almost as efficient as those of the best direct-current type, with small additional expense.

One other point of advantage obtained by the use of the compensating bands should be mentioned: as the cross-magnetisation of the armature is practically destroyed there is no change of lead under variation of load, as there is no distortion of the field magnetism by the armature current. These results are eminently satisfactory. In describing the Tesla motor, I pointed out that there was a loss of voltage, or that of the voltage applied, a considerable portion was unavailable. In our motor, 96 to 98 per cent. of the voltage applied to the armature is available, while the operating conditions are identically the same as found with a continuous-current motor. will not interfere with the operation of our motors more than it would with any continuous-current motor.

Fig. 6 illustrates the general design arrangement of the motor system. The condenser is placed either upon the wall or under the motor in the base. The E.M.F. applied to the field is about 150 volts; the armature E.M.F. is either 50 or 10 volts. The E.M.F. on the condenser is, approximately, 750 volts. While this E.M.F. may appear excessive at first sight, there is no real danger from its use, as a contact across the terminals would instantly reduce the potential, and accidental contact is easily prevented by properly insulated wires.

There is one other type of motor to be mentioned—the series-wound motor. When operating any of the ordinary types of motors by alternating currents, it is necessary that the phase of the field magnetism must coincide with the phase of the E.M.F. applied to the armature circuit—that is to say, the field magnetism must arrive at its maximum value at the same instant the

E.M.F. applied to the armature arrives at its greatest value; for if these two values do not coincide in time, the counter E.M.F. developed by the rotation of the armature will not directly oppose the E.M.F. applied to the armature, but will be skewed off one side, and consequently will allow a large false current to flow in the armature circuit. Fig. 7 illustrates the point, for suppose they do not coincide in phase, then A-B represents the maximum value of the alternating E.M.F. applied to the armature, and B-C represents the lagging magnetisation, which, as I have stated, should coincide with A-B; consequently B-S represents the counter E M.F. of rotation, which is, of course, directly opposed to B-C and should be directly opposed to A-B, or should occupy the position of B-E. It can be shown that D-F is the E.M.F. urging the current against the resistance of the armature, or C-R, while E-F, which is smaller than D-F, would be that E.M.F., providing the magnetism B-C coincide with A-B. All this simply means that, when operating a motor by alternate currents, the magnetism in the field should coincide with the E.M.F. applied to the armature, or else there will be a false current in the armature circuit. The condenser accomplishes this desired result in the shunt type of motor; in the series-wound motor the magnetisation necessarily coincides with the armature E.M.F., because they both accompany the same current. The series-wound type of motor, then, is the simpler to deal with; let us examine it for a moment. If an alternate-current source be applied to a series-wound motor properly constructed with laminated fields, etc., the motor will run with feeble torque, and if one investigate the cause of this want of torque and power, it will be found at once to be due to the inductance of the motor; the E.M.F. of self-induction will greatly reduce the available E.M.F. applied to the motor, and consequently lower its capacity to translate electric energy into mechanical power. We have removed this deleterious effect of the E.M.F. of inductance in the following manner: Fig. 8 represents a motor having its field and armature connected in series, while *c* is a condenser also connected in series; the distribution of the E.M.F. is given in the diagram. The transformer supplies the motor with current at 50 volts pressure, the E.M.F. of self-induction located almost entirely upon the field coil is assumed to be 60 volts, the E.M.F. on the condenser is, consequently, 60 volts for the current in circuit and the load on the motor, and consequently, if the current varies, then both the condenser and self-induction E.M.F. vary in approximately the same manner, thus leaving the circuit to receive current from the transformer and to do work. In my judgment, this type of motor will be of great practical use; not only will these motors successfully handle all constant load problems, such as pumping, blowing, etc., but they will be exceedingly useful in crane and elevator work, while their service in propelling cars can hardly be estimated. In all cases where hand control is required, they can be operated as successfully as continuous-current motors.

The most serious question we have met in pursuing this problem has been that of finding a suitable condenser. It may be well to state that none of the ordinary types of condensers—viz., those made of paper, paraffin, glass, mica, etc.—are of the slightest use. We have found that the residual charge in all the above-mentioned substances absolutely prevents their acceptance; this residual charge seems to depend upon the non-homogeneity of the dielectric and upon the want of an absolute contact between the plates of the condenser and the dielectric surface. When glass is used as a dielectric and a potential of 1,000 volts (average) is maintained upon the condenser, the glass heats rapidly until, finally, it is shattered to pieces. Condensers of glass, when raised to a potential of 15,000 volts, became phosphorescent, rapid flashes of light appeared in various parts of the glass, while they withstood the potential, which was only for a few moments. Vulcanite we find unreliable; metallic chips are always present, and for this reason, if for no other, it fails to stand satisfactorily. We have succeeded in producing what we call "films" from ·003 to ·005 of an inch thick, which will surely stand a potential of 1,000 volts. We believe that these condensers are entirely commercial, and that they will not deteriorate, while their cost per microfarad is quite low. So perfect are they that they show but little trace of residual charge, they do not heat perceptibly when in circuit for a long time, and withstand a potential of from 2,000 to 3,000 volts with a dielectric thickness of ·006in. The processes of their manufacture will not be made public at present.

Of the three types of motors mentioned in the beginning of my paper, I have but partially described one; the other two can be worked out. We believe we know how to perfect the synchronous type; we expect to do so. The Tesla motor is perhaps the simplest of the three to work out from the beginning, but, like all such problems, it requires study and careful investigation. The so-called multiphase motors, of which much has lately been written, possess no advantage over the two-phase type as devised by Mr. Tesla; in fact, the two-phase motors are neither better nor worse, but the European multiphase motors appear to have been carefully designed; the relations between field and armature seem better, and, if they possess any superiority over the American rotary motors, it is derived from these conditions rather than from any new departure in the application of the three-phase currents.

Mr. Kelly and I have produced motors which are operative on existing circuits. As we have stated, our motors start at full torque, run to a definite speed and behave exactly like direct-current motors under load. So perfectly does our compensating winding eliminate the E.M.F. of self-induction from the armature circuit, that this circuit offers very nearly the same opposition to alternate currents of a frequency of 130 complete periods p. s. that it offers to continuous currents; there is, therefore, little falling off of speed due to the self-induction of the armature circuit—in fact, we can over-compound the motor by its own load by setting the brushes off the neutral point of commutation, thus changing the flux through the field.

Your president has asked me to address you on the alternate-current motor problem, and I presume he expects me to offer an excuse on behalf of the profession for not having placed in your hands a perfected motor adapted to your circuits before this time. I can only say that the problem has been a difficult one. There are so many opportunities offered to alternating currents to dissipate their energy, so many more than are found with continuous currents, that one has to be very keen-sighted to avoid undue waste in constructing alternating machinery; but, from the knowledge already acquired, I feel convinced that the coming year will place the alternate-current motor more firmly on its feet, and that before the year elapses many stations represented in this convention will be testing the accuracy of the statements contained in this paper.

LIVERPOOL LIGHTING.

REPORT OF THE CITY ENGINEER.

We quote the following from the *Liverpool Courier* of Wednesday:

"'What is to be the light of the future?' is a subject which is being seriously considered both by corporate bodies and private individuals. A great commercial community like Liverpool is deeply concerned in this matter, and the Corporation and the leading officials have recently been giving it much attention. The Council not long ago passed a resolution: 'That the Watch Committee be instructed to consider and report to the Council as to the advisability and best method and probable cost of using the electric light in lieu of the present mode of lighting the city,' and 'That the city engineer report to the Lighting, etc., Sub-Committee.' In pursuance of this, Mr. H. Percy Boulnois, the city engineer, has prepared an able and exhaustive report dealing with the whole subject of the suggested lighting of Liverpool by electricity.

"In commencing his report, the engineer thinks that it would be of interest to the committee and to the Council (as it will certainly be to the public), if he recapitulated the history of the question of lighting the public streets of Liverpool by electricity. It appears that this question first came before the Council on October 30th, 1878, when a resolution was passed directing the then borough and water engineer to report to the Council with reference to electric lighting, and its applicability for lighting the public streets. In January, 1879, the British Electric Light Company applied to the Watch Committee and obtained permission to give an exhibition of the electric light at the large lamppost opposite St. Nicholas's Church, the company bearing all the expense. In the meantime the consideration of the report of the engineer was finally postponed in February, 1879, until the Corporation obtained an Act, at that time being promoted in Parliament, and which was entitled 'An Act to make further provisions for the lighting of the Borough of Liverpool,' and to 'extend the powers of the Corporation in relation to the supply of light by electricity.' The primary object of this Bill seems to have been to confer upon the Corporation powers, for a limited period, to make experiments in connection with electric lighting, and to light certain portions of the city by electricity. The Act was obtained in due course, but its powers expired in September, 1884, and have not been renewed. In pursuance of the powers conferred by that Act, the Watch Committee, in September, 1879, directed the Lighting, etc., Sub-Committee to obtain plans, estimates, and tenders for the lighting by electricity of the east side of St. George's Hall, and the open spaces surrounding.

"In October, 1879, the engineer was instructed to report to the Watch Committee as to utilising the Wellington column for the purposes of electric lighting, and also a site near the weighing machine house, Old Haymarket. This report was presented, when the then engineer pointed out that the concentration of the light had certain objections, and that the use of more numerous lights of less intensity placed at moderate heights would produce a more satisfactory effect, and he suggested that four lights should be placed, one each at the Wellington Monument, the south-east portico of St. George's Hall, the south-western tower of the North-Western Hotel, and the tower of the Imperial Hotel. But with reference to the lamp on the Wellington Monument, he pointed out that a very objectionable shadow would be thrown by the monument unless two lights were provided, and which would be a wasteful mode of procedure. The cost of this lighting was estimated at £600 per annum, if the engine employed at the Picton Reading-room was used to generate the power. The Watch Committee recommended the Council to adopt the engineer's report, and asked the Library Committee to grant the use of their engine for the above purposes. On October 29, 1879, the Council granted the necessary permission. In November, the Library Committee passed a resolution postponing the consideration of the resolution of the Watch Committee until the electric lighting in connection with the Picton Reading-room had been brought to maturity.

"Nothing further seems to have been done until October 12, 1880, when the Watch Committee passed a resolution requesting the late engineer to furnish a detailed report upon the subject of lighting the streets and places of public resort of the city by means of electricity, and the late engineer reported on the 16th November, 1880, to the Watch Committee, and in this report he recommended that advertisements should be issued

inviting tenders for the lighting of various streets in the city by electricity for periods of three, six, or twelve months, at a fixed sum, to include all plant and working expenses; and suggested certain streets and open spaces where a trial might be made. A special meeting of the Watch Committee was held in the same month to consider the report, when it was approved. In December, 1880, the engineer submitted tenders for lighting the open spaces, and the tender of the British Electric Light Company, Limited, was accepted. In April of that year the contract with the British Electric Light Company was finally settled and signed. In May, the engineer reported that the company had not commenced lighting the streets, according to the conditions of their contract, and further delays were, from time to time, reported. There also appears to have been some difficulty in connection with the overhead wiring, and an application was made by the company, in October, 1881, for permission to lay the wires underground, which was declined. In January, 1889, the company withdrew from their contract. In May, 1889, the late engineer was directed by the Lighting, etc., Sub-Committee to report as to the best way of lighting the city by electricity, and the probable cost, distinguishing the lighting of some part, or parts, as an experiment, and also as to the comparative cost of lighting by electricity, and of obtaining the same amount of light by improved gas appliances; and in September of that year he presented a short report upon the subject, dealing with the electric lighting Act of that session, and stating that the experience of the cost of street lighting by electricity had been very small, and did not furnish sufficiently reliable data to base a comparison of cost as between it and gas, except that the cost of electric lighting, when confined to streets alone, greatly exceeded the cost of gas. The late engineer concluded his report by stating that in view of the numerous applications that would be made for licenses or provisional orders under the Act of 1882 he did not think it advisable for the Corporation at present to take any action in the matter.

"The Lancashire Maxim-Weston Electric Company, Limited, in January, 1884, commenced lighting certain streets with 20 lamps, and the late engineer reported from time to time upon this lighting. In April the company was wound up, and in June the gas lamps in the locality were religeted, from which time the electric lighting ceased. Nothing further seems to have been done until the year 1888, when the Liverpool Electric Supply Company, Limited, obtained a license authorising them to erect and maintain electric lines and works, and to supply electricity within the city of Liverpool, and afterwards in the year 1889 they obtained a provisional order.

"Mr. Boulnois gives the result of enquiries made with regard to street lighting in other places. Replies were received from 270 towns, with a result that out of the total of 348 towns communicated with the engineer was only able to hear of nine towns the streets of which are partially lighted by electricity, and 14 towns which had previously lighted some of their streets by electricity and had subsequently abandoned it for various causes.

"Coming to the immediate question as to the advisability and best method and probable cost of using the electric light in lieu of the present mode of lighting in the city of Liverpool, the engineer expresses the opinion that there is no necessity for replacing gas by electricity, unless a largely increased amount of light is secured, or the same amount of light can be secured at a less cost. The factors which so largely determine the preference for electric lighting inside buildings—such as pollution and heating of the air, consumption of oxygen, artistic effect, etc.—do not apply where open street lighting is concerned. As to the best method, the engineer is of opinion that the best electrical method at present known is that of lighting the streets by means of arc lamps of from 1,200 c.p. to 2,000 c.p. (nominal) each, placed at such heights and in such positions as will secure the maximum effect of the light. With regard to the probable cost of using the electric light in lieu of the present mode of lighting the city, it will be seen, on reference to the engineer's reports on other towns, that the introduction of electric light in place of gas lamps invariably costs more, but this cost is accompanied by greatly increased efficiency of illumination.

"The engineer is of opinion that overhead wiring would not be for one moment tolerated in Liverpool as a permanent means of supplying energy to the lamps; consequently his estimates are based upon underground cables, and include lamps and standards of an ornamental character. The estimate is as follows: First cost: electric installation, including land, buildings, machinery, dynamos, etc., cables, arc lamps, and standards, say, £35,750; annual cost: supplying energy to and maintenance and cleaning, etc., of lamps for the district shown on plate No. 2 accompanying this report, less contribution from the Mersey Docks and Harbour Board for lighting the landing stage, etc., £7,900; interest and sinking fund on £28,650, say, £1,958; total estimated cost per annum £9,858."

WALLASEY LIGHTING.

The following is the report of Mr. A. Bromley Holmes, M.I.C.E., to the Wallasey (Cheshire) Local Board:

In reply to your request for a report as to the practicability and cost of lighting your district, or any section of it, with the electric light, utilising any power that might be available at Seacombe and Egremont ferries, and also as to how far the proposed new gas works could be utilised for both gas and electrical works, I beg to submit the following for your consideration.

I have been furnished with a map of the district, and have inspected the site of the proposed new gas works, and made myself acquainted with the principal residential and business districts where the electric light might be required. I have also inspected the plant at the Seacombe and Egremont ferries. Ample space for a generating station could be without inconvenience provided at the new gas works, and as for a scattered district, like the one under consideration, a high-tension system of distribution would be necessary, the position of the gas works would not be unsuitable for such a station. The plant now in use at the Seacombe and Egremont ferries could not be utilised for electric lighting. There is no engineering difficulty in supplying the light to any portion of your district in which there might be a sufficient demand for it. As the cost of lighting the streets by electricity would exceed the cost of lighting them by gas, I assume that you would not entertain any scheme which did not offer a reasonable prospect of remunerative return on the capital expended from the revenue to be derived from private consumers. It is therefore necessary to consider: 1. The amount of capital expenditure required. 2. The price at which electricity could be supplied. 3. The demand that might be expected for the electric light.

In my opinion the smallest station that could be worked with reasonable prospect of success would be one capable of supplying, say, 5,000 16-c.p. incandescent lamps, or the equivalent. The cost of such a station, including the necessary distributing mains and transformers, engines, dynamos, and all accessories, complete ready for work, I estimate approximately at £30,000. This sum includes the cost of the necessary buildings, but not of the land. From a station of this size in full operation you should be able to supply electricity to the public at the price of 7d. per Board of Trade unit, covering all working expenses, and providing 3½ per cent. interest on capital expended and a redemption fund of, say, 3 per cent. Electricity at 7d. a unit is practically equivalent to gas at 6s. per 1,000 cubic feet. I understand the present price of gas is 3s. per 1,000. The matter therefore seems to depend on whether a sufficient number of consumers can be found to adopt the electric light at a cost about double that of gas. The advantages of the electric light as regards health, comfort, and cleanliness are so great that in Liverpool and other large towns there is a large and rapidly increasing demand for the electric light at higher prices than that named above. I ought to point out to you that although the cost of electricity would be at first double that of gas, there is no doubt that this cost will be gradually reduced (especially when the incandescent patents expire in 1893), and it is reasonable to anticipate that within a very few years electricity will be supplied at a cost equivalent to the present price of gas. In my opinion you would be justified in undertaking the supply of electricity if you could obtain applications in the first instance for, say, 2,000 lamps, provided the applications were from consumers grouped closely together at two or three points in your district. The cost of laying down mains for such a small number of lights, if scattered over a large area, would be quite prohibitory. I think it probable from my inspection of the district that there will not be at present sufficient demand for the electric light to make it worth while for your Board to undertake the supply, but this can only be ascertained by a canvass of the possible consumers.

TAUNTON.

The following is the report of the Joint Finance and Watch, Lighting, and General Purposes Committee *re* purchase of the electric lighting company's undertaking, to be presented to a special meeting of the Town Council, to be held at the Council-chamber on Tuesday, the 22nd of March, 1892.

Your committee report that the town clerk has been in correspondence with the Board of Trade and the Local Government Board, as to the purchase of the electric lighting company's undertaking, and the committee herewith present their letters. He has also had an interview with one of the heads of the electric lighting department of the Board of Trade, and has gone through the draft of their letter with him. In addition to the matters set out in the letter, the official informed him that a license might be obtained in about four months after the necessary advertisements had been published, but that a provisional order could not come into operation until August, 1893; their fees on the order would be £50, a reasonable time would be allowed for the removal of the overhead wires, but ours being an exceptional case he could not say what time would be granted. In the opinion of the Board the order need not contain any reference to the purchase, but the town clerk informed them that the Local Government Board would require a full description of the property to be purchased in the order. Should the Council decide to purchase, your committee suggest that a license (which could be granted by August next) shall be obtained for a limited period, say three years, and that the Local Government Board be asked to hold an enquiry in the autumn of this year, and to give their sanction for a loan to be repaid in three years if the Council do not obtain the provisional order, and for 30 years if they do so; the Council could then take over the works, and carry on the business until the provisional order could be obtained, which would probably be in August, 1893, until which time it would be impossible to borrow the money to pay the purchase-money. The Board of Trade should also be asked to allow the Council three years before they should be required to carry the wires underground. The following are copies of the letters of the Board of Trade and Local Government Board to the Town Council hereinbefore referred to.

Board of Trade (Railway Department), London, S.W.,
15th February, 1892.

Electric Lighting Acts, 1882 and 1888.

Sir,—In reply to your letter of the 10th inst. I am directed by the Board of Trade to inform you that they are not aware that any difficulty is likely to arise which would prevent the Corporation of Taunton from obtaining statutory power to supply electrical energy for public and private purposes within the borough, but that if they desire to apply for power to supply outside the borough the consent of the local authority of such outside district should first be obtained. I am further to inform you that, while the Board of Trade are of opinion that the time has come when applications for statutory powers should be made by means of provisional order rather than by means of license, they would, in the circumstances referred to, be prepared to consider the advisability of granting a license on the understanding that the Corporation would apply for a provisional order at the earliest opportunity. I am, however, to point out that Section 3 (5) of the Electric Lighting Act, 1882, provides that no license shall be granted by the Board of Trade until after the expiration of a period of three months from the date of the first publication of the notice required by that section, and to inform you that it is usually found impracticable to complete the preliminaries necessary to the issue of a license until after the expiration of some four or five months from the date of application. I am at the same time to state that the Board of Trade, as at present advised, would not be prepared to approve of the use of overhead wires for the supply of energy under a license or provisional order as a permanent arrangement, at any rate in the central and populous portions of the town, and that any license or order granted to the Corporation would require the removal of any such existing wires within a reasonable time. With reference to the enquiry contained in the final paragraph of your letter, I am to state that the Board of Trade are not aware of any case in which a local authority has purchased an installation under the circumstances referred to. A copy of the rules made by this department, with respect to applications for licenses and provisional orders, is enclosed herewith, together with a copy of a model form of provisional order.—I am, Sir, your obedient servant,

The Town Clerk, Taunton. COURTNAY BOYLE.

Local Government Board, Whitehall, S.W.,
29th February, 1892.

Sir,—I am directed by the Local Government Board to advert to your letters of the 10th and 19th inst., with reference to the proposal of the Town Council of Taunton to purchase the undertaking of the Taunton Electric Lighting Company, and in reply to state that the Board are unable to refer you to any case where a sanitary authority have purchased the undertaking of an electric lighting company. The Board assume that the Town Council contemplate effecting the purchase under the provisions of Section 2 of the Electric Lighting Act, 1888, and in such a case the Board consider that, before the Town Council can be empowered to borrow for the acquisition of the undertaking, they must be in the position of an authority authorised to supply electricity by the license or order of the Board of Trade. The Board understand that the Town Council have communicated with the Board of Trade in this matter, and it is proposed to obtain from that department a license under Section 3 of the Electric Lighting Act, 1882. When the Town Council have obtained from the Board of Trade the requisite authority to supply electricity, the Board will be prepared to entertain an application for sanction to a loan to defray the cost of the purchase. In connection with such an application the Board will require to be furnished with (1) a copy of a resolution of the Town Council authorising the application; (2) a copy of the Board of Trade order, or license, as the case may be; (3) a full description of the works proposed to be purchased, with particulars of the dates at which the several parts were first constructed or provided, and with a valuation by an independent valuer who has had experience of similar undertakings; and (4) information in the enclosed form as to the financial position of the district. I am to add, that if the authority by which the Town Council may be authorised to supply electricity should be a license under Section 3 of the Act of 1882, the Board would limit the period for the repayment of any loan which they might sanction to the period for which the license is granted. By reference to the section it will be observed that this period cannot exceed seven years.—I am, Sir, your obedient servant, C. N. DALTON, Assistant Secretary.

To T. Meyler, Esq., town clerk, Taunton.

THE BOROUGH SURVEYOR'S REPORT TO THE JOINT COMMITTEE.

Mr. Mayor and Gentlemen,—I have made a very careful inspection of the buildings and plant at the central station of the Taunton Electric Lighting Company, and herewith produce detailed reports under their several headings.

Buildings and Land.

The buildings have but recently been erected, and with few exceptions appear to be nearly as they left the builder's hands; but, nevertheless, it is necessary that 5 per cent. per annum be deducted for depreciation. The cost of the buildings, including architect's fees, was as follows:

	£	s.	d.
Contract sum, with extras and architect's fees	2,491	5	3
Less 5 per cent. per annum for two years	249	3	0
	£2,242	2	3
Cost of land	850	0	0
	£3,092	2	3

Boilers, etc.	£	s.	d.
Two Babcock and Wilcox water-tube boilers, 105 h.p. nominal, each supplied with water through a feed-water heater by two Worthington pumps, the working pressure being 140lb. per square inch, and all steam-pipes, cost complete	881	0	0
The iron tank and girders, etc.	51	5	0
Fire ladder	32	5	0
Carried to summary	£964	10	0

Engines, etc.	£	s.	d.
Two horizontal compound non-condensing engines, by Ruston and Proctor, of Lincoln, with speed of 125 revolutions per minute, indicating 75 h.p. each, with 140lb. boiler pressure. Cost, fixed	568	2	0
Two vertical high-speed central-valve engines, non-condensing, by Willans and Robinson, indicating 135 h.p., at 350 revs. per minute. Cost, fixed	919	10	0
These engines are connected to two alternators. Cost, fixed	1,008	0	0
The Ruston and Proctor engines drive a countershaft from which the arc dynamos are driven by clutch pulleys, so that any machine can be stopped or started independently of the others for the arc lighting. There are four of these dynamos of 30 arc-lighting power each, the cost of which was	2,000	0	0
And the countershafting cost	213	11	0
The link belting for same	196	8	0
Elwell and Parker dynamo	180	0	0
Armature, spare	34	8	0
Carried to summary	£5,119	19	0

Mains, Posts, etc.	£	s.	d.
Wire, cost	804	1	6
Labour to ditto	304	17	11
Poles—Allen, etc.	800	0	0
Insulators	50	0	0
Labour to fixing poles	186	12	0
Switchboards and measuring instruments	128	0	0
Carried to summary	£2,273	11	5

Accumulators.	£	s.	d.
Those at Mr. Massingham's, those at St. John's Church (½ h.p. motor)	202	13	11
Lamps of all sorts, some having been in work a long time	831	0	0
Transformers fixed to the clubs, and other places	303	0	0
	£1,336	13	11
50 per cent. off	668	6	11½
Carried to summary	£668	6	11½

NOTE.—There are a few items, such as an iron barrow, a clock, etc., which £20 would cover.

Summary.				£	s.	d.
Buildings and land				3,092	2	3
Boilers	£964	10	0			
Engines, etc.	5,119	19	0			
Mains, posts, etc.	2,273	11	5			
Accumulators, etc.				668	6	11½
	£8,358	0	5			
Less 10 per cent. for two years	1,671	12	0			
				6,686	8	5
				£10,446	17	7½
Lightning conductor				25	0	0
Two series lamps				6	0	0
Sundries				20	0	0
				£10,497	17	7½

OBSERVATIONS ON THE PLANT GENERALLY, AND SUGGESTIONS FOR THE MORE EFFICIENT WORKING, REDUCING THE EXPENSE, AND THE COST OF APPLIANCES FOR SUCH PURPOSE.

The plant is in good condition, but at least 10 per cent. per annum should be deducted for depreciation. Everything appears to be in good repair.

The system for supplying the electricity is called the high-tension for alternating arc, and low-tension for the accumulators. There is a loss of 30 per cent. from the use of accumulators, but the incandescent lamps last longer on account of the even tension to be obtained by their aid. The high tension carries the high pressure up to the houses. The distributing mains, therefore, are of small size, and a large district can be served from one station, and the regulation of pressure in the distributing mains can be arranged with the greatest nicety within a variation of 2 per cent.; therefore, should it be desired to extend the lighting to the outer area of the borough, such an extension can be readily made.

The boilers in use are of the modern type, and are used extensively in conjunction with electric lighting. A considerable saving might be effected in this department; the excessive waste of oil, waste, and water, could be reduced at least 50 per cent. The water should be used again and again, and the loss would be only due to evaporation. An oil filter is required, so that the oil may be run to the bearings in a simple manner; the saving would be very considerable. A mechanical stoker would also, to a certain extent, prevent the very large volumes of smoke escaping, which

is so much complained of as a nuisance. The coal used costs £2 per diem. This can be very materially reduced by partitioning off the stack, or forming a diaphragm to check the excessive draught when only one boiler is used; this, with a smoke-consuming apparatus, would about render the works thus far perfect. The cost of Elliot's patent "smoke annihilator," perfection guaranteed, would cost about £80. The boilers are in fairly good condition, they have been in work only about two years, and have been so reported by the boiler examiners for the insurance company up to July last.

The engines are in good condition. Those made by Messrs. Ruston and Proctor, of Lincoln, drive a countershaft 5in diameter, from which the arc dynamos are driven by clutch pulleys, so that any machine can be stopped or started independently of the others. The two vertical high-speed central valve engines are connected to two alternators by 12in. link belting, and are wasting power (if their indication is correct): this we have no means of testing at present. All engines which run under different loads should have their indicators fixed; the steam can be regulated accordingly, and a saving effected also. With the above engines, a simple case is demonstrated. There are but 515 incandescent lamps wired, and only 75 per cent. of these run nightly, thereby making a very considerable loss; whereas, to work economically with such high-pressure engines, there should be at least 1,300—16 c.p., or the equivalent of candle-power—which would then be only a fair load on the engine. This would mean 785 lamps more could be had by the same power which is being spent on the 515, or this number, run as proposed, would bring to the revenue over £500 per annum, as set forth in detail hereto annexed.

The profits derived from the supply of electricity to private consumers would increase rapidly with the extension of the demand, as the staff and other expenses would be sufficient to work a much larger number of lamps than those enumerated. The charge of 6d. per Board of Trade unit for private lighting would be equivalent to 3s. 6d. per 1,000ft. of coal gas, and in some towns they consider an 8-c.p. incandescent lamp will light interiors equally as well, if not better, than the gas jets of which they are supplied by the gas companies, with the illuminating power of 14 candles. The prices vary somewhat in different towns, but an average charge is as follows:

		Per annum.
8 c.p.	bedrooms	£0 8 0
10 ,,	sitting-rooms	0 14 0
10 ,,	passage and hall	0 16 0
1,200 ,,	arc, 2,000 hours	23 15 0
16 ,,	incandescent, 3,250 hours	6 15 0
32 ,,	,, ,,	9 18 0

It is not possible to give an exact estimate of the cost of extending the supply to a larger area, but it may be taken roughly at £50 for each arc light and lamp complete, and £10 for each 32-c.p. incandescent.

I should also mention that the cost of production of electricity and electric lighting is being rapidly cheapened by improvements in dynamos, and more especially in the lamps; the patent upon the latter expires January, 1893, when the price will be about 1s. 6d. for each incandescent lamp. (The cost now is 3s. 9d. each lamp.) The introduction of recording meters would be satisfactory to the consumers, as well as to the generators of the electricity. I find that 1 i.h.p. may be taken to produce 140 candles in incandescent lamps; the same power would be equal to 860 candles of arc light, therefore it will be readily seen that the arc system of lighting is by far the best for all main thoroughfares. At the same time, some towns are using the incandescent lamps in side streets, by placing them in the old gas lanterns, which is found to be economical; therefore 32-c.p. lamps would have to be used in main streets, so that there would be 196 32-c.p. lamps available, and this would mean as many gas jets shut off at £2. 8s. per annum.

I calculate the saving on coal at least	£100
Oil and waste	50
Water	35
	£185

I have before stated that for each incandescent lamp the cost would be £10; that, of course, is the estimate where there are no wires, but where the wires are run, the cost, by using Swinburne and Co.'s transformer-lamp combination, would be reduced to £6 each—*i.e.*, instead of running the lamps in series, transformers would be used.

There are contracts existing with several firms I thought better to leave out of this report. I have endeavoured to give the present value of everything which could be seen, and to carry out the instructions of the Joint Committee.

The mains are carried overhead on iron poles, about 30ft. in height, and the lamp suspended about 24ft. from the ground. The alternating current at present is 14 amperes, 2,000 volts, so this would be dangerous if carried into the houses, therefore a transformer is placed outside the house, which reduces the current to 100 volts, and is therefore harmless. The lamp can be lowered for cleaning, etc., by a small windlass arrangement, but this at present is very defective—the ropes should be of steel. The wire used for the mains is $^7/_{18}$ hard-drawn copper, insulated with okonite, and of which there are about seven miles used in the several circuits. The insulators are of Johnson-Phillip's fluid type throughout, and appear to be in good condition.

There are six circuits formed from the central station—*i.e.*, two for alternating system, two for public arcs system, and two for private arc system.

There are 31 public arcs of 1,200 c.p. each, and 41 private arcs *of the same illuminating* power, but the lamps are made for double carbon for public lighting, and but single carbons for private lighting. The switchboard for the arc dynamos is of the plug type. By its use any machine can be connected to any circuit without interrupting the supply of current to the lamps. The alternator switchboards are fitted with measuring instruments of various description and rheostats, by which means a certain current can be at all times maintained. To the latter is also fixed one of Cardew's voltmeters, and Thomson-Houston ammeters, the whole being in good working order. There are also other measuring and testing instruments, the whole of which I have taken at £128. The works are in working order throughout.

February 25, 1892. JAMES H. SMITH, Borough Surveyor.

Your committee present the following statements, showing the present income and expenses of the electric lighting company, the probable increased income by the adoption of the meter system, and the capacity of the works for extension:

STATEMENT No. 1.—Showing Amount Now Being Earned and Cost of Working.

Income.			£ s. d.
Income for year 1891, as per account delivered by Mr. A. Goodman			1,521 1 3
Deficit			746 9 6
			£2,267 10 9
Expenditure.	£ s. d.	£ s. d.	£ s. d.
£1,897. 2s. 9d. as shown by the account delivered by Mr. A. Goodman.			
Wages	219 6 3		
Salaries	222 14 4		
Coal and firewood	738 1 8		
Waste and oil	162 5 4		
Carbons	109 13 6		
Electrical renewals	86 13 10		
Engineering renewals	112 15 1		
Repairs and renewals	25 11 8		
Rates and taxes	111 2 5		
Water	71 8 0		
Printing and stationery	13 10 4		
Carriage and haulage	33 18 10		
Sundry trade expenses	12 9 11		
Sundries	19 2 10		
Stamps and telegrams	8 8 9		
	1,947 2 9		
Less loss on exhibition	59 0 0		
		1,897 2 9	
Estimated deductions, payments, etc., deduct saving in coal, oil, waste and water (as per surveyor's report)		200 0 0	
			1,697 2 9
Annual payment to loans fund in respect of principal and interest on purchase		£10,000 0 0	
Cost of obtaining order, etc.		342 0 0	
Cost of oil filter		25 0 0	
Smoke consumer, diaphragm in chimney, and pumping apparatus		133 0 0	
		10,500 0 0	
Discount on issue of stock		682 0 0	
Total capital		£11,182 0 0	
to be repaid in 30 years, annual payment			570 8 0
			£2,267 10 9

STATEMENT No. 2.—Showing the Amount which would be Earned with the same Consumption of Energy, if Supplied to the Present Consumers by Meter, at 6d. per Board of Trade unit.

Income.	£ s. d.	£ s. d.	£ s. d.
31 street lamps at £22. 10s. each	697 10 0		
41 arc lamps at £10 each	410 0 0		
		1,107 10 0	
500 incandescent lamps at 6d. per unit (average three hours)	817 10 0		
One continuous machine at 6d. per unit (average four hours)	173 0 0		
		990 10 0	
			2,098 0 0
Rent of meters			50 0 0
Deficit			145 0 9
			£2,293 0 9
Expenditure		£ s. d.	£ s. d.
Working expenses as per statement No. 1			1,697 2 9
Annual payment to loans fund in respect of principal and interest as per statement No. 1		570 8 0	
Ditto ditto cost of meters, £500, repayable in 30 years		25 10 0	
			595 18 0
			£2,293 0 9

STATEMENT No. 3.—Showing the Capacity for the Production of Current without Extra Engines or Dynamos.

Income.	£ s. d.	£ s. d.
72 arc lamps (31 public, 41 private) ...	1,107 10 0	
13 extra ditto for street lighting at present contract price—viz., £22. 10s. per lamp per annum	282 10 0	
Five private ditto at £10 each	50 0 0	
		1,440 0 0
500 incandescent lamps by meter, at 6d. per unit	817 10 0	
800 extra ditto, at 6d. per unit	1,308 0 0	
One continuous machine as above	173 0 0	
		2,298 10 0
Rent of meters...............		50 0 0
		£3,788 10 0
Expenditure.	£ s. d.	£ s. d.
Working expenses as per statement No. 1..	1,697 2 9	
Additional coal, etc., necessary for increased supply of energy, say......	200 0 0	
		1,897 2 9
Payment to loans fund in respect of principal and interest as per statement No. 2	595 18 0	
Additional capital required for extension of works—wires, tubes, new lamps, and posts £1,000		
Extra transformer........ 120		
1,120		
Add discount on issue of stock 80		
£1,200		
to be repaid in 30 years	60 0 0	
		655 18 0
Profit		1,235 9 3
		£3,788 10 0

STATEMENT No. 4.—As Statement No. 3, excepting Light to be Charged at a Lower Rate.

Income.	£ s. d.	£ s. d.
44 arc lamps for public lighting at £20 per lamp per annum...........	880 0 0	
46 arc lamps (private) at £10 each.....	460 0 0	
		1,340 0 0
1,300 incandescent lamps at 4½d. per unit		1,594 2 6
One continuous machine, at 4½d. per unit		129 15 0
Rent of meters...		50 0 0
		£3,113 17 6
Expenditure.		£ s. d.
Working expenses, as per statement No. 3............		1,897 2 9
Payment to loans fund as above		655 18 0
Profit		560 16 9
		£3,113 17 6

WM. M. CHAPMAN, Mayor,
Chairman of Finance Committee.

H. J. VAN TRUMP, Alderman, Chairman of Watch, Lighting, and General Purposes Committee.

COMPANIES' MEETINGS.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY.

The fifth ordinary general meeting of this Company was held at 1, Great George-street, S.W., on Thursday evening, 10th inst., Mr. Granville R. Ryder, chairman, presiding.

The report having been taken as read,

The **Chairman** said it would be seen that the Company had made very substantial progress during the last year. They had jumped from 25,535 lamps to 38,408—an increase of 12,873. The number of houses and shops lighted had increased from 291 on December 31, 1890, to 436 on December 31, 1891—an increase of 145. There had been an increase in the capital account of £21,780—viz., £13,350 in preference shares, and £7,930 in 4½ per cent. debentures. That £21,780 had been laid out in this way: mains and improvements, £8,000; plant, £7,500; batteries, £4,200; instruments and meters, £1,200; buildings, £1,000. The renewal account stood last year at £1,398. 14s. 1d., and had been increased in the year—he was dealing with 1891—to £1,713. 5s. A satisfactory feature of the accounts was that the production of electricity, which in 1890 cost £2,915. 8s. 8d., had last year cost only £4,067. Whereas in 1890, with nearly £3,000 spent on production, they only made a profit of £1,404; last year, with an increase in the cost of production of only £1,000, they had increased their profits to nearly £4,000. Therefore, an increased cost of only one-fourth had produced between two and three times more profit. He thought they might fairly say that, taking the accounts generally, they were satisfactory. They could have wished that they had had more business. This was the only point upon which they were rather disappointed. They expected to have got up to 40,000 lamps, whereas they had only arrived at 38,408. Since that time (December, 1891) the number of lamps had increased by about 1,000, but had not reached 40,000. What was quite clear from these figures was that there was a very good future of profit in the Company, and that a large proportionate increase of profit might be expected from every increase of business. This was exemplified by some figures which the Secretary (Mr. Erskine) had worked out, showing how much out of the 8d. per unit charged by the Company the costs of every kind came to. He (the Secretary) found that for last year the costs amounted to 5½d. out of every 8d. leaving a profit of 2½d.; whereas in 1890 the costs were 6½d. out of 8d. Thus they had gained 1d. out of every 8d., as compared with the preceding year. This showed the potentiality of profit in the Company. As to the gross revenue to be derived from each lamp, he was able to put it at 10s. for the year preceding the last (1890), but they found now that it was no more than 9s. It was difficult to say what might be the cause of this. His own impression was that the public were getting more used to the electric light, and knew better how to treat it. A new customer burnt the light in a harum-scarum way all over the house, but after the first quarter's bill found it necessary to be more economical, and the amount of current he consumed had fallen considerably. It took customers some time to get out of the gas habit and into the electric light habit. At the same time he was not dissatisfied with the result, because, after all, everything that tended to cheapen electric light was to their interest, and though they were not making so much out of it temporarily, it was much more likely to become the light of the future if cheapened in every possible way. With regard to the capital account, it was the object of the Directors to keep this down as much as possible. In a company of this kind, however, it was impossible to progress without constantly getting fresh capital, and the great point was not to get it unless they could see their way to make a profit on it. As far as this year was concerned, it did not seem likely that they would want more than £14,000 or £16,000. They wanted capital for main extensions, and for more new plant at both stations, but to no great extent. He then moved the adoption of the report and accounts.

This was seconded by **Mr. G. H. Hopkinson.**

In answer to several questions and criticisms, the **Chairman** said that he quite agreed it would be an advantage to show in the accounts the number of units sold, and this should be done on future occasions. He thought they had made a very good start, and did not see how they could jump to dividends at once in a business of that kind. They could not get the whole of London to reconstitute its lighting at once. During the last year they had made very great advances. Almost all the shops in the Brompton-road were using the electric light now. With a very small increase in their working expenses they could now get a much larger profit. The Directors had not taken any fees, and he thought the salaries were not at all high. They had two stations, and a more or less scientific staff, who must be paid, and he thought £886 was by no means an excessive amount. The law charges were considerably increased by their having to petition against several Bills in Parliament. The £5,353 against sundry debtors represented the consumers' bills for the last quarter (Christmas) which was a heavy one. That Company would not bear the whole of the expenses in the Lane Fox case, because it was being fought by an association. He then put the resolution, which was carried unanimously.

The **Chairman** moved the declaration and payment of a 2 per cent. dividend on the ordinary shares.

Mr. R. W. Wallace seconded, and it was carried unanimously.

On the motion of shareholders, Mr. A. S. Boulton and Sir Frederick Bramwell were unanimously re-elected directors.

Sir F. Bramwell returned thanks for his re-election, though it was not usual to do so, in order to answer a shareholder who had criticised the amount paid away for salaries. The business they were pursuing required the greatest care and attention. If their lights failed even for a short time it would do more to discourage the increase of electric lighting in their districts than any amount of apathy on the part of those endeavouring to promote it. This involved their having gentlemen of ability and thorough trustworthiness in every way at their stations, and he was glad to say they had them. He was ashamed to think of the salaries they had only been able to pay, which were very low having regard to the capital of the Company and the work. He was quite content to go without his fees until the Company could afford to pay good salaries, but he was not content that the Company should employ gentlemen and not pay them.

On the motion of **Mr. Schwann**, the auditors, Messrs. Lovelock, Whiffin, and Dickinson, were re-elected, and a vote of thanks accorded to the Directors and Chairman.

COMPANIES' REPORTS.

DIRECT SPANISH TELEGRAPH COMPANY.

The report of the Directors for the half-year ended December 31st, 1891, states that the accounts for the half-year show, after providing for debenture interest, a balance to the credit of profit and loss of £5,028. 12s. 11d. The traffic receipts show a decrease of £2,214. 4s. 9d. as compared with those for the corresponding period of 1890. The falling off in the receipts is chiefly due to the reduction of rates which the Company had to submit to at the International Telegraph Conference, held at Paris in 1890, and which came into force on July 1st last. The working expenses are

£17. 4s. 5d. in excess of those for the corresponding period of last year. Of the balance of profit and loss, £2,500 has been put to the reserve fund, which now amounts to £26,445. 19s. 4d., leaving £2,528. 12s. 11d. Out of this amount the Directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 4 per cent. per annum (free of income tax) on the ordinary shares, making, with the previous distribution, 4½ per cent. for the year 1891. A balance of £31. 13s. 4d. is carried forward.

BUSINESS NOTES.

Sims-Edison Torpedo.—Major-General Alexander H. Elliot, C.B., and Captain H. F. Twynam have joined the Board of the European Sims-Edison Electrical Torpedo Company.

National Telegraph Works Company.—As the result of an action brought by Mr. Hedges, on behalf of himself anh other debenture holders, against this company, Mr. Justice North has appointed a receiver.

City and South London Railway.—The receipts for the week ending 13th March were £876, against £749 for the corresponding period of last year, being an increase of £127. The receipts for last week, as compared with those for the week ending March 6, show a decrease of £17.

Notice of Removal.—We are informed that the Metropolitan Electric Supply Company have removed their offices from 4, Waterloo-place, S.W., to 17, South-street, Manchester-square, W., adjoining their Manchester-square station. On and after to-day all letters should be addressed to the new offices.

The Eastern Telegraph Company announce the payment, on April 14 next, of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum, on the preference shares for the quarter ended March 31; and the usual interim dividend of 2s. 6d. per share on the ordinary shares, tax free, in respect of profits for the quarter ended December 31 last.

Dissolution of Partnership.—The partnership between Messrs. Barnett, Wynne, and Barnard, trading as engineers, at Walker Gate, near Newcastle-upon-Tyne, has been dissolved by mutual consent. All debts due from and to the above firm will be paid and received by Messrs. R. W. and J. A. Sisson, chartered accountants, 13, Grey-street, Newcastle, who will also receive offers for the works and premises at Walker Gate, which are for immediate sale as a current going concern.

Kensington Court Electric Lighting Company.—At a meeting of the shareholders of this Company, on Thursday afternoon, 10th inst., the Directors, Messrs. A. S. Bolton, G. R. Ryder, and R. W. Wallace, submitted a report stating that they considered that the time had arrived when this Company, which was practically non-existent, and which had been merged into the Kensington and Knightsbridge Electric Lighting Company, should be formally wound up. A resolution to that effect was submitted to the shareholders and carried.

Brush Electrical Engineering Company.—The Electric and General Investment Company invite subscriptions for £125,000 of 4½ per cent. perpetual debenture stock, issued by the Brush Company at £1 per cent. premium. The stock is issued for the purpose of redeeming the existing £75,000 6 per cent. mortgage debentures of the Company, and of providing additional working capital. The subscriptions are payable as follows: £10 per cent. on application, £41 per cent. on allotment, and £50 on 1st May, 1892. A discount of £3 per cent. per annum will be allowed on payment in full on allotment. The last balance-sheet of the Company showed a surplus of assets over liabilities of £464,723. The new stock will operate as a first charge by way of floating security upon the whole undertaking and property of the Company, present and future, with the exception of the Vienna undertaking, pending a contemplated rearrangement of the Company's interest therein.

PROVISIONAL PATENTS, 1892.

MARCH 7.

4458. **An electrode for electro-plating.** Reginald William James, 1, Queen Victoria-street, London. (George Ellsworth Gale, United States.)

4464. **An automatic electric loom and card-cutting machine.** Henry Boswell Lee and John Clifford Cook, 11, Pratt-street, Camden Town, London.

4494. **Improvements in electromagnetic solenoid apparatus.** Frederick Vilhelm Andersen, 40, Chancery-lane, London.

MARCH 8.

4523. **Regulating sockets or holders for incandescent electric lamps and other translating devices.** The Ries Electric Specialty Company, 18, Fulham-place, Paddington, London. (Complete specification.)

4524. **Improvements in controlling the levers of railway signal interlocking apparatus by the application of electricity.** William Frederick Burleigh, 40, Chancery-lane, London. (Complete specification.)

4543. **Electrical measuring instruments.** George Wilson, 1, *Dare-villas, Aberdare,* Glamorgan.

4576. **Improvements in secondary batteries.** John Vaughan Sherrin, 77, Chancery-lane, London.

4578. **Improvements in and relating to applying carbon filaments to electric lamps.** Augustus Celanus Carey, 77, Chancery-lane, London. (Complete specification.)

4579. **Improvements in galvanic batteries and battery liquids.** Sally Adolf Rosenthal and John Vaughan Sherrin, 77, Chancery-lane, London.

4586. **Improvements in magnetic separators for ore and similar material.** Charles Trotter Thompson and Richard Hawes Sanders, 24, Southampton-buildings, London. (Complete specification.)

4610. **Improvements in electric gas-lighting burners.** George Franklin Pinkham, 45, Southampton-buildings, London. (Complete specification.)

4617. **Improvements in electrical attachments for pianos.** Fritz Anton Feldkamp, Jacob Schoenhaar, and Emil Eduard Lehr, 45, Southampton-buildings, London. (Complete specification.)

MARCH 9.

4691. **Improvements in secondary electric clocks.** Emi Schweizer, 28, Southampton-buildings, London. (Complete specification.)

4709. **An improved method of and means for electric wiring.** Reginald Frederick Yorke, 1, Queen Victoria-street, London.

MARCH 10.

4758. **Improvements in the method and means of obtaining electricity.** William Boggett, 34, Southampton-buildings, London.

4764. **Improvements in insulators for electric wires.** Henry Harris Lake, 45, Southampton-buildings, London. (Charles Nash Hammond, United States.) (Complete specification.)

4768. **Improvements in electric batteries.** Samuel William Maquay, 55, Chancery-lane, London.

4773. **Improvements in the manufacture of electrical conductors.** George Frederick Redfern, 4, South-street, Finsbury, London. (Sigmund Bergmann, Germany.) (Complete specification.)

4779. **An improvement connected with electric arc lamps.** John James Rathbone and James Houghton, 166, Fleet-street, London.

MARCH 11.

4816. **Improvements in electrical cables.** Wallace Fairweather, 62, St. Vincent-street, Glasgow. (Eugene Francis Phillips, United States.) (Complete specification.)

4820. **Improvements in primary batteries.** Léon Mercky, 226, High Holborn, London.

4841. **Improvements in the methods of driving electric railway trains.** Wilfrid L. Spence, The Elms, Seymour-grove, Manchester.

MARCH 12.

4930. **Improvements in and relating to fusible cut-outs.** Paul Manchin, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1891.

1050. **Distributing electrical energy.** De Ferranti.

3127. **Electric circuits.** Cruyt.

6243. **Galvanic batteries.** Marcus and others.

6247. **Galvanic batteries.** Johnson (Gendron.)

21541. **Dynamo-electric machine inductors.** Pyke and Harris.

1892.

406. **Electric motors, etc.** American Elevator Company. (Otis Bros. and Company.)

576. **Electric heat alarm.** Fitzpatrick. (Electric Heat Alarm Company.)

638. **Telephonic switching appliances.** Rabbidge.

825. **Electric cables.** Fairweather. (Phillips.)

1143. **Electric elevators, etc.** American Elevator Company. (Otis Bros. and Company.)

1147. **Telephones.** Newton. (Rabbidge.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3⅝
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5⅝
Metropolitan Electric Supply	—	9
London Electric Supply	5	1¼
Swan United	3½	4½
St. James'	-	8⅜
National Telephone	5	4⅜
Electric Construction	10	6
Westminster Electric	—	6¾
Liverpool Electric Supply	5	5
	3	3

NOTES.

Transformer Fires.—A house has been burnt down at Melun (France) through a faulty transformer.

Elmore Process.—The Elmore works at Dives have, it is stated, recently produced 300 tons of copper without fault.

Paris - Brussels Telephone. — The works on the third circuit of the Paris-Brussels telephone are nearing completion.

Physical Society.—Mr. R. W. Paul is to read a paper before the Physical Society at the meeting this (Friday) afternoon on "Some Electrical Instruments."

Steatite Insulators.—The lava electric insulators made by the Steward Company, of Chattanooga, are made from crude steatite mined in the neighbourhood.

Belgian Telephones.—It is officially announced that the Belgian telephone system will be taken over by the Government on Jan. 18 next. A great extension of the lines is in contemplation.

Wigan.—At the meeting of the Wigan Gas Committee last week, the town clerk reported that the powers of the Corporation to supply electricity under the Wigan electric lighting order, 1890, expire in August next.

Basingstoke. — The Urban Sanitary Authority are inviting tenders for lighting the borough by electric light. Tenders are to be sent in by the 30th April. Further particulars will be found in our advertisement columns.

Wolverhampton Tramways.—The Wolverhampton Town Council, on the recommendation of their General Purposes Committee, have withdrawn their consent to the use of steam on the tramways of the Midland Tramways Company.

Phonopore.—Trials, having satisfactory results, have been recently carried on with the phonopore telegraph between Lausanne and Villeneuve on the Jura-Simplon line. It is stated that the company will probably adopt the system.

Leeds.—A correspondent writing to the *Leeds Mercury* notices that a new gasholder is to be erected, and wishes to know, when the electric light is to be introduced, whether this would not cause the erection of more gasholders to be a waste of ratepayers' money.

Nottingham.—The Town Council require a resident engineer in connection with the carrying out of their provisional order. A salary of £300 per annum is offered to an experienced man, and applications for the post should be sent to the town clerk by the 16th April.

Heckmondwike (Yorks.).—At the meeting of the Heckmondwike Board of Health last week, the minutes of the Electric Lighting Committee, empowering Mr. Hutchinson, C.E., to go fully into the estimates and report upon the matter to the committee, were approved.

New Submarine Cable.—A contract has been concluded between the Java Government and the Eastern Extension Telegraph Company for the laying of a cable between Olehleh and Labuan Deli. By this means direct telegraphic communication between Acheen and Batavia will be secured.

Chiswick.—At the last meeting of the Chiswick Local Board the Works Committee recommended, with reference to the Chiswick electric lighting order, that the clerk be instructed to bring up at the next meeting of the committee a draft advertisement inviting applications for taking over the provisional order.

Creede.—This is the name of a new American town with 8,000 inhabitants, which has sprung up in a few months, owing to Mr. N. C. Creede's discovery of silver. The place is already lighted by electricity from a plant which was in operation within five days of the ground being taken for building.

Transmission of Power.—The spinning factory of the Gebruder Zoppritz in Mergelstettin is now worked by electrical power derived from water power at a distance of 1·4 kilometres from the mill. It is said to be working excellently. The plans were carried out by the firm Schuckert and Co., of Nuremberg, and J. M. Voith, of Heidenheim.

Jamaica Cables.—A Dalziel's telegram from New York, March 17, says: "Advices received here to-day from Kingston, Jamaica, dated March 8, state that the Halifax and Bermuda Cable Company has made a proposal to the Jamaica Government for an extension of its lines to Jamaica *viâ* Turk's Island. The company demand an annual subsidy of £2,000."

Aston Manor (Birmingham).—The following result of tenders is given in this week's *Contract Journal*: "For complete electric installation at baths and public offices, for the Aston Manor Local Board (Mr. W. A. Davies, A.M.I.C.E., Aston Manor, engineer): Fowler and Lancaster, Birmingham, £1,594 (accepted); Verity and Son, Birmingham, £1,661. 7s. 6d."

Rotary Current.—Prof. W. Eiler, of Esslingen, describes and illustrates in the *Elektro-technische Zeitschrift* for March 11 a simple arrangement for demonstrating rotary current, consisting of two cells, a current direction changer, and a stand with two coils wound at right angles and rotatory armature. Experiments with a rotary field can be easily carried out with this apparatus in a laboratory.

Perth Tramways.—The Perth and District Tramways Company has been issued with a capital of £15,000 in £5 shares, for constructing tramways in Perth and to New Scone. The company is applying for a provisional order, the necessary consents having been obtained. It is intended to use electricity as the motive power on the accumulator system. The cost of plant and construction is given at £13,500.

Dover.—At a special meeting of the Dover Town Council last week Alderman Adcock enquired what progress had been made with reference to the contract for electric lighting by the Brush Company. The town clerk said he hoped to be able to submit a communication to the committee next meeting. Alderman Adcock said they did not want their streets up in the middle of the season to lay the wires.

Folkestone.—At last week's meeting of the Folkestone Town Council a letter was received from Mr. Henshaw Russell, inviting the Corporation to visit the Electrical Exhibition at the Crystal Palace. Alderman Banks proposed that the Mayor should take them up, and entertain them for the day. It would only cost £40. Councillor Pursey seconded, amidst laughter. We do not hear that the Mayor agreed.

Sydney Technical College.—The Minister for Public Instruction, New South Wales, has appointed Mr. Arthur C. F. Webb, M.I.E.E., to be lecturer on electrical engineering at the above college. Mr. Webb, who was formerly with Prof. George Forbes, is technical assistant to Mr. E. C. Cracknell, superintendent of Government Telegraphs, New South Wales, and has charge of the technical school attached to that department.

Board of Trade Rules.—At the meeting of the Commissioners of Sewers on Tuesday, the clerk read a

letter received from the Board of Trade asking if the Commissioners had any observations to make in respect to the rules, which they enclosed, for the regulation of the public safety in the matter of electric lighting. It was resolved to refer this communication to the Streets Committee, Mr. Preece, Colonel Haywood, and the other officers.

Crystal Palace Smoking Concert.—A smoking concert is to be held to-night (Friday) at 8 p.m., at the Crystal Palace, in the Grand Saloon. Captain Henshaw Russell will take the chair. An excellent programme has been arranged by the stewards, and a fine selection of songs and music, ranging from "Ora Pro Nobis" and Wieniawski's mazurka to "Ta-ra-ra"—but we needn't finish—will be given. The concert promises to be a great success.

Edinburgh Tramways.—The Leith Corporation have had before them the question of co-working of the Edinburgh tramways. During the discussion a letter was read from the agents of the Edinburgh Tramways Company intimating the withdrawal of the clauses authorising the construction of cable lines or electric traction. A conference of the towns interested was held on Tuesday, and it was decided that it was necessary for the tramways to be worked as one concern.

Barnsley.—At the Barnsley Town Council meeting on Tuesday, the Park and Lighting Committee reported the receipt of a further report on electric light in the provinces from the borough surveyor, and their intention to visit Bradford for the purpose of inspecting the electric light plant there. Mr. Raley asked if the committee proposed to bring the electric light to the town. Mr. Haigh said that was more than he could tell, but the visit to Bradford was with the object of making a recommendation to the Council.

Australia.—Electricians may expect a spurt presently in lighting business in Australia, thinks the Melbourne *Building and Engineering Journal*, as many of the country municipalities are seriously considering the advisability of lighting their towns by electricity. At Kiama business is to be done, and in the Shoalhaven district generally there is a forward movement in this matter. It speaks volumes for the advance of this business, that towns adjacent to inexhaustible coal supplies should prefer electricity for lighting purposes.

Liverpool Mains.—It will be remembered that a short time since explosions occurred in several of the boxes containing electric wires underneath the paving of certain streets in Liverpool. Major Cardew was recently sent down by the Board of Trade to make an examination. A copy of his report to the Board on the subject was submitted on Monday to the Watch Committee. This provoked a great deal of discussion. Ultimately the city engineer was instructed to make an inspection of the street boxes, and present a report to the committee.

Southend Pier Tramway.—At the last meeting of the Southend Local Board, the Pier Committee submitted a letter from Messrs. Crompton and Co., expressing their willingness to inspect the pier electric plant five times during the season, and once in the interval, and give a written report after each inspection, for the sum of £21 per annum. These terms were agreed to. The Pier Committee also recommended that Messrs. Crompton and Co. be requested to supply and fix an electricity meter at the pavilion, at the amount of their estimate—viz., £15.

Cable Machinery.—A class of machinery that will naturally tend to increase under the present extension of electric lighting is that of cable machinery. A special department of the well-known electrical engineers, Messrs. Johnson and Phillips, is devoted to this class of work, and *amongst other large works* fitted by them for the manufacture of insulated cables and wires and vulcanised rubber leads have been the cable works at Milan, the works at Calais recently started, and a new factory which is being established at Grammont, in the South of France.

Leeds Electric Tramways.—The electric tramways to Roundhay Park, Leeds, are working in a satisfactory manner. Since the lines were opened, some four months ago, upwards of 200,000 passengers have travelled on the two routes, and the comfort and ease of travelling gives general satisfaction. It is proposed to extend the Beckett-street line along York-street to Kirkgate Market, in the heart of Leeds. This extension will prove very useful, and the probabilities are that other extensions may follow as the advantages of the system are more fully recognised.

Southport.—At a special meeting of the Southport Town Council, held on Tuesday evening, the following resolutions *re* electric lighting scheme were adopted unanimously: "1. That the installation be fixed at or near the present gas works, and be worked on the high-tension alternating-current system. 2. That plans for the necessary buildings and plant be prepared as soon as possible. 3. That Mr. G. Wilkinson, of London, formerly of Southport, be appointed engineer for the work, his inclusive remuneration to be at the rate of 3 per cent. on the outlay."

Gas Engines in Central Stations.—A curiously mixed up combination of gas and electricity has been recently started in a town in Connecticut. The makers of the Otto gas engines in Philadelphia have constructed for the gas company of the town referred to, two 100-h.p. gas engines—the largest yet made in America. Three of these engines are to be coupled on a single shaft to drive dynamos in the gas company's central electric lighting station. The engines are to have two cylinders, one above the other, working upon a single crank, and the gas for driving is to be producer-gas.

Derby Deputation.—Last week a deputation from the Corporation of Derby, accompanied by the Mayor, Mr. Alport, and the Lighting Committee of that town, also their consulting electrical engineer, Mr. H. Graham Harris, visited Bath for the purpose of inspecting the electric lighting arrangements. After being shown over the works by the company's chief engineer, they expressed themselves much pleased with the general arrangements both for public and private lighting, and also thanked the directors for their kindness in allowing them to inspect the machinery. The deputation paid a second visit to the works the next morning.

Serpollet Steam Engine.—The instantaneous steam heater of MM. Serpollet Frères, mentioned in these columns about a year ago, has been very successfully applied, it seems, to the driving of carriages and the running of small dynamos. Water is pumped into very solid pipes, the sides of which are pressed together, leaving but a very narrow interior passage. The coiled pipes are heated in a special furnace, and the generation of steam is instantaneous. For certain situations the Serpollet steam engines, like Mr. Pitman's "Demon" water motors, might have useful application for providing power quickly on a small scale.

Leicester Refuse Destructor.—We notice that a contract has been awarded to Messrs. J. E. Johnson, of Highcross-street, Leicester, at £5,943 for the erection of a refuse destructor, with engine and dynamo house, for the Leicester Sanitary Committee; Mr. E. G. Mawbey, C.E., borough surveyor. We have pleasure in calling attention to this use of the waste heat of the destructor for electric lighting. If we remember aright, this is not the first example

of the production of electric light by the same means in Leicester, another destructor having been fitted with a dynamo and engine, under the superintendence of Mr. Mawbey, some time ago.

Liege University.—The Montefiore Electrotechnical Institute of the University of Liège has issued a prospectus of the courses, which is particularly interesting to electrical engineers and those wanting to send their sons abroad. The classes include very complete courses in electrical engineering (in French), the fees being 220f., 240f., and 270f., (about £9, £10, and £11) for the first, second, and third year's course, with a small extra fee for examination. A large number (17) of distinct nationalities are represented out of a total of 205 students, five students only being English. The prospectus can be obtained on application to the secretary, 31, rue St. Gilles, Liège.

Oil Transformers.—The Thomson-Houston Company are now making oil transformers in six standard sizes, from 12 to 150 lights capacity. The containing cases are sealed hermetically after the oil is poured in, and a separate box is used to contain the switch and main fuse. Each 1,000-volt transformer is tested to 5,000 volts alternating. Another safeguard adopted is the grounding of the core: the sheet-iron plates are insulated from the iron casing, and a ground wire is attached to the core plates. This is to protect against lightning. With the core thus grounded, a lightning discharge is conducted to earth, and the insulation which had been pierced is immediately closed by the oil in the transformer.

Buchanan Castle.—Messrs. Drake and Gorham are now engaged in introducing the electric light at Buchanan Castle for the Duke of Montrose. The current is to be obtained from water power, for which purpose a head of nearly 90ft. is available. The water will be conveyed in pipes to the lowest point, at which the turbine and dynamo will be placed. From this spot the current is conveyed up the hill to the Castle by means of a simple system of troughs laid amongst the shrubs. This system of conductors has been introduced by Messrs. Drake and Gorham as the result of the experience they have gained at Lord Armstrong's, where it has been employed for some years past. It is not only readily accessible, but is much cheaper than any other method.

Leicester.—There does not seem to be much chance of the establishment of the electric light by the Corporation in Leicester just at present. The last we heard about this town was that a proposal was before the Town Council for the establishment of several small stations at various points for the production of electric light by means of gas engines. In answer to a question at the last Town Council meeting, Councillor Billings said the Gas Committee felt that electric light was so hedged round with patents, and it had proved so unsatisfactory and unprofitable to public bodies who had adopted it, that they considered waiting was the safest plan. They would have to adopt the electric light and they intended to adopt it, but they wished to postpone it for a little at present.

Gordon Closed-Conduit Tramway.—Negotiations to place the Gordon electric tramway system on a sound financial basis have been in progress for some time, and are, we believe, coming to a satisfactory point. Practical tests are being undertaken by a well-known electrical engineer, and if the results come up to those obtained by the inventor, we may hope to see the system brought prominently forward shortly. We are aware that the Thomson-Houston Company have spent some thousands on experimenting with conduit systems, closed and open, without success, but Mr. Gordon seems to have tackled the subject in quite a different manner to any hitherto brought forward, and we should certainly be pleased to see his system proved to be a practical method of running cars.

An Electric Mail Car.—One novelty in the way of electric traction on the St. Louis and Suburban Railway, now in successful operation in St. Louis, says the *Scientific American*, is the application of electric motors to a United States mail car, which makes regular trips over the entire line, distributing and collecting the mail at the different railway stations, as is done on steam railways. This car is of the same length as an ordinary steam railway mail car, and is equipped with double trucks with 36in. wheels, a Thomson-Houston motor of 15-h.p. capacity being connected to each truck. A very high speed is attained, and the delivery and collection of mail is made without stopping the car, as in steam service.

Electric Carriages.—An electric road carriage has been built in Boston, U.S., and attains a speed of 10 to 15 miles an hour on the level. The motor is mounted centrally on the front axle, with the armature above and parallel to the axle. On each end of the armature shaft is a crank disc, from which extend connecting-rods to clutches below the axle, these clutches being mounted on short shafts revolving beneath the axle, having pinion gearing to the hub of the wheel. The motor runs at 1,000 revolutions at 40 volts, current being supplied by storage cells. The carriage has been built entirely in Boston. Mr. E. D. Chaplin is the inventor of the motor and gearing, Dr. Orazio Lugo's storage batteries are used, and the enterprise is carried on by the Electric Road Carriage Company, of 95, Milk-street, Boston, Mass.

Kennedy Alternate-Current Motors.—A paper on a new system of electrical distribution in towns and cities was read on Tuesday by Mr. Rankin Kennedy, of Carntyne Electric Works, the inventor of the system, before the Institute of Shipbuilders and Engineers at Glasgow. Electric motors and transformers were shown in action. The system has for its object a comprehensive scheme of distributing electrical energy over large towns economically, and of providing a supply of such a nature that it will be safe and useful for all purposes to which electricity may be applied. The motors can be worked without commutators or brushes, and therefore without sparking, and no attendance is required. The system is a multiphase system of alternating currents, and Mr. Kennedy can supply a continuous current from special converters, and claims all the advantages attendant upon the use of both alternating and continuous currents from one common generating station

Edinburgh Deputation at Glasgow.—A deputation of the Town Council of Edinburgh, consisting of Bailies Macpherson and Dunlop, and Messrs. Kinloch Anderson, Colston, and Robertson, visited Glasgow last week in connection with the proposed lighting of the city by electricity. The object of the deputation was to ascertain what had been done up to the present by the Corporation of Glasgow with reference to electric lighting; and the points upon which they particularly wished to be informed were the system of lighting which had been adopted and the probable cost of the installation which the Corporation of Glasgow have just begun to put down for the lighting of the central area of the city. The deputation were received at the City Chambers by members of the Glasgow Gas and Electric Lighting Committee, along with Mr. Foulis, gas engineer, and Mr. Arnot, electrical engineer. Full information was laid before the deputation as to the various details of the Glasgow scheme of electric lighting.

Electric and Cable Railways.—In the House of Commons on Monday, Mr. Whitmore moved: "That the resolution of the House of March 1, relative to electric

and cable railways (metropolis), which was ordered to be communicated to the Lords, and the message from the Lords of March 7, signifying their concurrence in the said resolution, be read; that the said Select Committee appointed to join with a committee of the Lords do consist of five members, to be nominated by the Committee of Selection; that a message be sent to the Lords requesting their lordships to appoint an equal number of lords to be joined with the members of this House." The motion was agreed to.—On the motion of Mr. Kimber, on Tuesday, it was agreed that it should be an instruction to the Joint Committee of the Lords and Commons relative to electric and cable railways (metropolis) that, as regards any schemes for which Bills have been deposited, they should have power to hear the parties promoting any such Bill before reporting whether it should be not proceeded with.

Proposed New Pacific Cable.—The following note is from the Melbourne *Argus*, February 15, 1892: "SYDNEY, SUNDAY.—The Premier states that, in common with other colonial Governments, New South Wales has been asked to subsidise an independent cable service which should start from Gladstone in Queensland, and go thence to New Caledonia, Fiji, Samoa, Honolulu, and then either to San Francisco or Canada. The French Government, according to Mr. Dibbs, have agreed to subsidise the lines as far as New Caledonia, the English Government as far as Fiji, and the German Government as far as Samoa is concerned. The money necessary to lay the cable has already been subscribed, and it is only asked that a small amount of business should be guaranteed by the colonies. Mr. Dibbs views the proposal with favour, and will notify the promoters to-morrow of the readiness on the part of this colony to give the guarantee asked for." It was stated in a note in our issue of February 19, from telegraphic information, that New South Wales had agreed to grant a small subsidy, but that Victoria was unwilling to do so.

Death by Electric Shock.—Dr. Walter Buchanan, in the *Lancet* for March 19, gives an account of the *post-mortem* appearences in a victim of electric shock, evidently the unfortunate man at Chatham. He saw the patient 10 minutes after the accident. Artificial respiration was resorted to, but death occurred after three inspirations. In conjunction with Drs. Voysey, Holroyd, and Burns he made a *post-mortem* examination 31 hours after death. Dr. Buchanan says, after giving technical details, which showed an entire absence of disease and general congestion: "We particularly noticed the tarry condition of the blood, as it has been stated that this is caused by the action of the electric current on the red blood corpuscles. The auriculo-ventricular rings were no doubt enlarged by muscular contraction. The cause of death was evidently by asphyxia. The case is interesting, as we get very limited evidence of deaths from electricity. In those occurring from lightning coroners rarely engage the services of medical men, and far more rarely order a *post-mortem* examination, taking other evidence for granted."

Leonard's Electric Lifts.—Mr. H. Ward Leonard's system of running electric motors by varying the current as the torque and the E.M.F. as the speed, has recently been successfully applied to electric lifts. The working of lifts and cranes usually involves problems of a nature distinct from other applications, and Mr. Leonard's object is to vary the speed of the lift without varying the rotary effect of the armature as long as the weight is not varied, and also to enable the speed and direction of movement to be controlled from the lift itself. The motor is mechanically connected to the lift and the connections are so made as to keep the strength of field constant, the speed being varied by varying the E.M.F. by a controlling device on the lift; this switch also serving to reverse the motion by reversing the field magnet of the generator. By this arrangement the motor has the same efficiency at different speeds and the same torque at different speeds if the weight remains the same. As the field is kept constant no sparking occurs, and the reversal is accomplished when the current is at a minimum—after having been gradually reduced, it is reversed and then increased to the amount desired.

Earth's Magnetism.—The theory of Mr. Henry Wilde, F.R.S., upon the earth's magnetism, and the deviation of the magnetic poles from the true geological poles, is discussed by Prof. Frank H. Bigelow in the *American Meteorological Journal* for January. Mr. Wilde's theory is that the interior of the earth, still in a liquid condition, revolves about the axis the earth had in its infancy, while the crust, jerked round at the time of the formation of the moon, has a different axis of rotation, skewed over 23½deg. The inner mass he regards as electro-dynamic, and the outer sheet as electro-magnetic. A machine composed of one sphere within the other, both encircled with coils of wire, with magnetised sheet iron at the places representing the ocean, and the inner and outer shells rotating 23½deg. apart, reproduce, it is declared, every known variation of magnetism of which there is record. Dr. Charles A. Schott, of the U.S. Coast Survey, informs Prof. Bigelow that he has magnetic variation records, of which Mr. Wilde was evidently ignorant, in which the theory still holds good. The period of time for one complete secular change is 960 years, which agrees with Sir William Thomson's values. The only doubt that occurs is whether the earth's centre is liquid, but Mr. Wilde considers this theory "to be as firmly established as that of the rotation of the earth on its axis."

London Subways.—The London County Council's Bill for controlling underground subways was before a Select Committee of the House of Commons on Tuesday, presided over by Mr. Herbert Gladstone. Mr. Littler, Q.C., in opening, said the Bill was promoted to obtain control of all subways for the reception of pipes at present laid beneath the surface of the road. The nuisance which the frequent breaking up of the London roads was to traffic would hardly be credited by the committee. At present there were only nine streets in London which had these subways beneath the surface. When the subways were first made there was a great outcry as to the dangers that would arise from gas explosions and the bursting of water mains, but in no single case in London had any accident arisen. The difficulty, however, was to get gas and water companies to use the subways. The Council, therefore, asked by this Bill for powers to bring about their more effectual use by compelling companies, under certain conditions, to remove their pipes into the existing subways. Mr. Binnie, engineer to the County Council, gave evidence in support of the Bill, and expressed the decided opinion that it was an unfounded fear on the part of the electrical companies that any danger existed from placing their pipes near gas-pipes. During the further cross-examination of Mr. Binnie clauses were agreed to with the London water companies, who thereupon withdrew from further opposition. The committee adjourned till next Monday.

Glasgow Central Station.—The Town Council have accepted tenders for the excavator and steel and iron work required in the erection of their central station at the corner of Waterloo and Mains Streets. Mr. Porter has the former at £7,182. 15s. 11d., and Mr. William Baird the latter contract at £1,529. 10s. 9d. It is intended in the first instance to put down plant to supply 12,000 8-c.p.

lamps, but the station will be large enough to accommodate machinery for supplying 40,000 such lamps. The engines and dynamos will be erected in the lower storey of the building, with the boilers immediately in rear of them. Five steel boilers of marine type, 10ft. in diameter and 12ft. long, will be fixed to start with. The battery-room will be above the boilers, and will contain two sets of 57 cells of 1,000 ampere-hours capacity each. Space will be provided for double this amount of battery storage. The contracts for engines and dynamos will probably be settled in a few days. There will be seven Willans engines, two of 80 h.p., two of 150 h.p., and three of 250 h.p., with seven continuous-current dynamos, two with an output of 400 amperes at 120 volts, two with an output of 500 amperes at 230 volts, and three with an output of 670 amperes at 230 volts. The conductors used will be strips of copper, led through porcelain insulators, placed in cast-iron troughs. The troughs and insulators will be made so as to permit of additional strips being put down without the streets being disturbed. The specification for the contract provides that any openings in the public streets shall be closed the same day on which they are made. It is mentioned that possibly some of the streets may be lighted this autumn from the new station.

Tesla Motors.—The statement that we made a few weeks ago, on Mr. Tesla's authority, that 1,000-h.p. alternate-current three-phase motors were built and working in America, caused a good deal of surprise amongst electrical engineers in this country. The Westinghouse Company, who control the patents, have been busy for some time past in standardising the sizes of motors from 1 h.p. to 1,000 h.p., and an illustration of one of these monster Tesla motors is given in the N.Y. *Electrical Engineer* for March 9, showing a machine about 10ft. or 11ft. high, judging from the height of the attendant standing by it. These machines run either as motor or as generator, and when run as generator will give 150 amperes at 5,000 volts. In mechanical design this machine is similar to the multipolar direct-current railway generators built by the Westinghouse Company. The armature is of the drum type, with slots for the wire, and is without bands. At starting the alternate-current motor has inductive resistance, and the loss at starting is thus much less than with the direct-current motors. The Tesla motor requires no commutator, and is consequently sparkless. It may be boxed up, and thus kept free from dust and grit. The armatures are wound to give either 60deg. or 90deg. difference of phase, and are built in two types—those which are entirely self-exciting and self-regulating, and those which are separately excited and self-regulating. If the pressure is not over 5,000 volts, the current may be supplied direct from high-tension mains. No starting resistance is required, and the motor practically requires no attendance. The smaller sizes are small and compact for their power, and high pressures can be used with them as well as with the larger sizes. A large extension of the use of alternate-current motor work is evidently in store for the immediate future.

Electrical Traction.—At the meeting of the Bradford Scientific Association on the 19th ult. an interesting and practical lecture was given by Mr. J. T. Riley, D.Sc., on "Electric Traction." After describing the construction of the dynamo and the means of generating current by the rotation of coils in a magnetic field and the interactions, the question of motors was gone into, and it was pointed out that the mechanical power developed by the motor in watts was equal to the product of the back E.M.F. in volts by the current forced through in amperes. The back E.M.F. is proportional to the number of conductors in the armature, the strength of the magnetic field, and the speed of rotation. Special attention was directed to the relation between torque and speed for the various types of winding. If the motor is fed with current at a constant pressure, the series machine has the valuable property of exerting a large torque at low speeds, while the true compound-wound motor, though capable of maintaining a constant speed, is incapable of exerting more than a certain maximum torque. The large torque at low speed is a valuable property of the series motor for traction purposes, since it allows of a large effort at starting. The racing of the machine at light load may be corrected by switching resistance into the circuit, and so reducing the current. The mechanical characteristics of the other types of winding under the same condition of supply and also under the condition of constant current were also considered. In any case, the electrical efficiency of the motor is the ratio between its back E.M.F. and the pressure between its terminals. The lecturer next described the methods in use for electric cars—overhead, elevated third rail, conduit, and accumulator systems; the construction was described, and the various lines in use were illustrated by lantern views. The suitability and economy of the four systems for various conditions of the road and traffic were also dealt with, together with the cost of power and maintenance, on those lines in which electrical traction has had a sufficiently extended trial. The lecture was much appreciated by a large audience.

Water Storage.—"Prof. Forbes has lately told the world," says the *Journal of Gas Lighting*, "that, in certain circumstances, water power can be made available to compensate for the difference between maximum and actual loads, which is such a serious obstacle in the way of the commercial success of central electric lighting stations. At the Crystal Palace there are huge elevated reservoirs doing nothing at this season of the year, but used in summer for supplying the great fountains. Why were they not employed to demonstrate the possibilities of turbine-driving for dynamos, with or without reference to Prof. Forbes's views? Or why was there no arrangement for transmitting power from the lower lakes in the Palace grounds to the Exhibition, either by a repetition of the Frankfort-Lauffen experiment, or otherwise? These are questions very much to the point, for which no satisfactory answer can readily be obtained. The exhibitors at Sydenham seem to prefer playing with search-light projectors, with the illumination of fountains, the display of inferior imitation fireworks, the cooking of cutlets, and so on, to seriously tackling any of the known problems of electric lighting industry." Our gas contemporary is viciously and wilfully hard upon all and sundry exhibits at the Crystal Palace Electrical Exhibition simply from the fact, apparently, that they are electrical. The illumination of rooms and fountains, and the cooking of chops, and the brushing of boots, etc., shown in actual work at this Exhibition, are the very best means of demonstrating the usefulness of electricity to the popular mind, and will always be far more interesting to the public even than the machinery. And who should depreciate demonstrations of cooking? Certainly not the gas journals, for it is exactly such demonstrations with gas that remain the only means of saving the gas companies' incomes—and even this hope may be lost to them eventually. With reference to schemes of distribution by water storage, there certainly is a fine chance for the demonstration of Prof. Forbes's system, and our gas contemporary is not alone in its ideas upon the subject. We may have something further to say in reference to this interesting subject a little later on, when perhaps a "satisfactory answer" can be obtained.

THE CRYSTAL PALACE EXHIBITION.

THE TELEPHONIC EXHIBITS.—II.

The General Electric Company, Limited, which, since the expiration of the master patents has taken up telephonic work energetically, exhibits a variety of transmitters, receivers, and accessories. The transmitters comprise a modified Hunnings of considerable efficiency as a long-distance talker; a two-pencil vertical microphone, known as the Manchester, suitable for short distances; and the latest pattern of Johnson transmitter. Immediately the Edison patent lapsed, there was a general enquiry for transmitters calculated to avoid the unexpired secondary patents, and as Crossley had magnanimously disclaimed any intention to chain two-pencil microphones to his patent chariot wheels, several inventors tried their hands in this direction, although as we pointed out last July * there was in reality no reason why Crossley's multi-pencil microphones should not be copied *ad libitum*. Mr. Johnson, of the Sheffield Telephone Company, had been in the field as early as 1880 with a two-pencil transmitter of considerable efficiency, but the legal victory of Edison had compelled him to stop manufacturing, although not before the Sheffield exchange had been supplied with a sufficiency of "protected" instruments to keep it going for a number of years. On Edison's patent lapsing, Johnson revived his transmitter with improvements, and it has already come into extensive use. The new form is shown in Fig. 7, which is a plan of the underside of a pine diaphragm carrying two carbon pencils, A A^1, resting in the carbon blocks B, B^1, B^2. The current enters at the contact, C, splits at B^1 between the pencils, and leaves at C^1. The speaking is loud and distinct, and the extreme simplicity and absence of any adjustments render the transmitter very unlikely to get out of order. The General Electric Company mount the microphone in a variety of ways. One of these, a neat and handy table set, is shown in Fig. 8. The best results are obtained with the diaphragm inclined at an angle of 28deg.

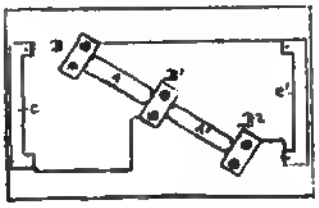


FIG. 7.

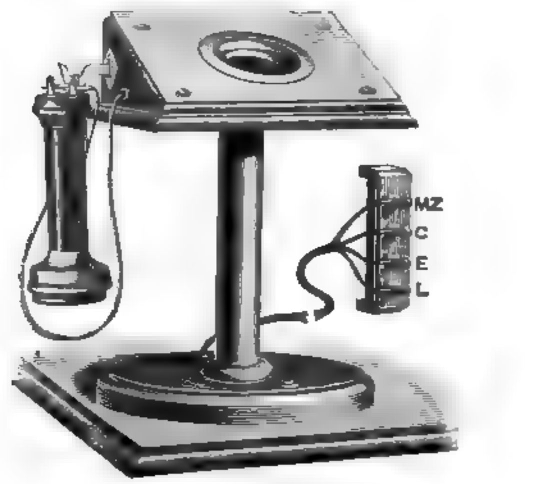


FIG. 8.

Another speciality is the intercommunication system for warehouses and factories recently patented by Mr. T. B. Sloper, of Devizes. The leading idea of such systems is that where several stations are in telephonic connection by means of a wire for each station and a common return, each may call up any other at will without the intermediary of an operator, and, when finished, leave the connections right for any further calls to its own or between the other instruments. Such systems, owing to the amount of wire required, are not adapted for long distances, but within the limits of single establishments undoubtedly possess their advantages and conveniences. In the earlier plans the restoration to *status quo* of the necessary pointer switch or commutator was either left to the talker's recollection or effected automatically by the act of hanging up the phone. Sloper arranges his connections so that no special device is necessary for this purpose; his stations can be called up in any position of the pointer. But the most novel feature of his invention is the attachment of a secret switch, by using which any two of the stations can converse together without being overheard by the others. This is effected by employing the direct wires of the two stations as a metallic loop, cutting out the common return, which can, however, be used simultaneously by any of the other stations. The secret switch is put out of operation after conversation by the act of hanging up the phone. The connections can readily be traced in Fig. 9, in which P P are the microphone and S S the secondary circuits; 1, 2, 3, 4, the line contacts of the switches; M, M, M, M the pointers; J, J, J, J the secrecy switches. The contacts marked "spring" are permanent ones, and prevent the instruments ever being left disconnected. The diagram shows an installation of four stations, two of which are using the secret circuit and two the common return. The company also exhibits a loud-speaking receiver for concerts, a variety of switches of ordinary patterns, telephonic translators, magneto bells, batteries, and line materials.

The Consolidated Telephone Construction and Maintenance Company, Limited, the most important of English manufacturers of telephonic apparatus, has a varied and excellent exhibit of apparatus, and has adopted the practical plan of establishing a branch stall in the South Gallery, in order that visitors may not only examine, but test the speaking of the telephones on show. The Gower-Bell, Blake, and Fitzgerald transmitters, for which the company is noted, together with a variety of receivers, may all be tried in this way with satisfactory results. The worst of the Consolidated exhibit is that it is mostly made up of instruments which are so well known that there is nothing new to be said about them; they have spoken so often and effectually for themselves. In this category must be included the company's system of warehouse intercommunication, which was one of the first of its kind, as it is still one of the best; the diver's equipment; and the portable lineman's set. An exception, as being exhibited for the first time, is the special transmitter and switch-bell constructed for the Mutual Telephone Company, of Manchester, the exigencies of whose system require a departure from the ordinary methods. Switchboards are well represented, three different patterns being shown. One of these, which was designed by Herr Krause for the Austrian Telephone Company, may be taken as typical of Austrian switchboards. The workmanship is good, and much ingenuity has been displayed by Mr. Graham, of the Consolidated Company, in working out the details. But here commendation must cease. Electromagnets are interposed in the talking circuits; ring-off drops fall if a subscriber rings, whether he has finished or not, and the movements required to make and then take off a connection are no less than 12, twice as many as with Scribner's single-cord multiple. Express trains in Austria average 27 miles an hour, and it would seem that Austrian telephony is making a worthy effort to live up to them. A plan of the connections is shown in Fig. 10. The plugs are arranged in pairs, each pair consisting of a black plug, P, and a white plug, P^1, connected by the flexible cords, C C^1, in the circuit of which is inserted a contact trigger, T, a ring-off drop, D, and a ringing key, K. The flexible cords of the white plugs, P^1, are kept taut by metal weights, W, which, when the plugs are out of use, establish contact between the springs, S S^1, thereby bringing into play the operator's phone, O, or the generator, M, according to the position in backward or backward gear of the lever, H, which has also a middle or neutral point. The Austrian system of switching requires that after the called subscriber has been rung he must ring back, and that the operator shall take

* Telephone Transmitter Patents, *Electrical Engineer*, July 10th, 1891.

cognisance of the fact. This throws a large amount of extra work on the operator, and in a busy exchange would greatly delay switching, since if a called subscriber does not answer instantly his connection must be held in suspense until he does, and reverted to, perhaps, after several interim ones have been made. The idea is in sympathy with the grandmotherly notions prevalent in some continental countries, where railway travellers, telephone subscribers, and others are treated like mere children and never accorded opportunities of exercising or developing any intelligent initiative. In the telephonic times that are coming inventors will have to work in an exactly opposite direction by seeking to divert work from the operators, where its concentration occasions severe pressure, to the subscribers, where, owing to the division of labour thus brought about, it is not felt at all. And subscribers, at least British ones, as experience already proves, not only do not resent being switched through and left to their own devices, but, after a little experience, will not tolerate any other plan. The movements required for this Austrian board are: 1. Operator plugs into caller's jack with a black plug, P. 2. Moves lever, H, forward and rings back to caller. 3. Moves lever, H, back and speaks to caller. 4. Plugs into called subscriber with a white plug, P¹. 5. Moves lever, H, forward. 6. Rings called subscriber by pressing key, K. The operation then ceases until the called subscriber rings back, which act drops one of the ring-off indicators, D. Operator then proceeds: 7. Moves trigger, T, and leaves subscribers through. 8. Replaces caller's shutter, A. 9. Replaces

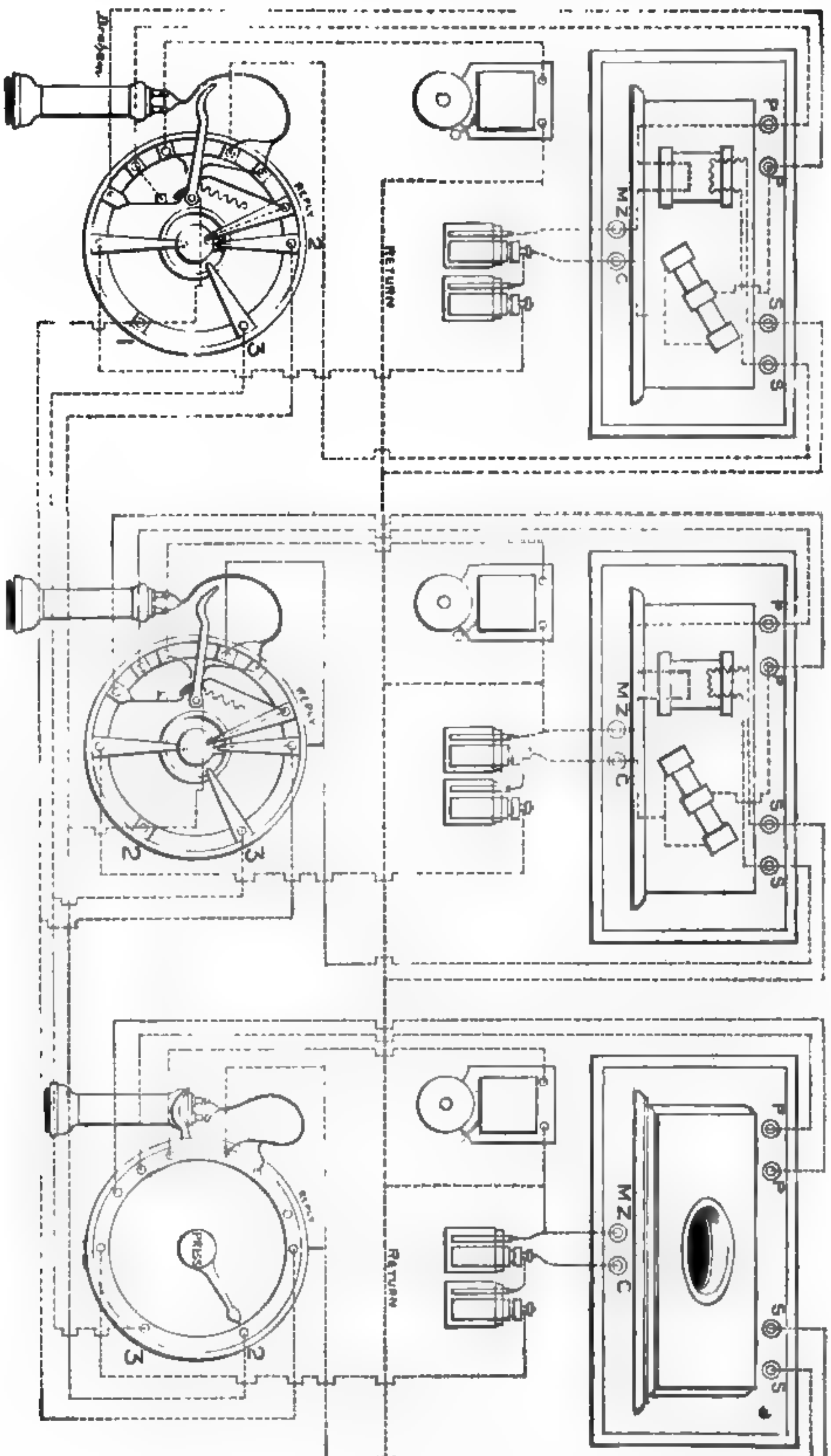


FIG. 9.

ring-off shutter, D. Then, when the completion of the conversation is notified, by the second falling of D: 10. Releases trigger, T. 11. Withdraws plugs. 12. Replaces D. The Consolidated Company is not, of course, responsible for the system. The second board, also for continental use, is a small one, intended for the operation of metallic circuit trunk lines in a single-wire exchange of considerable size. Each section of the subscriber's board has one or more junction wires to the trunk board on which callers for trunk connections are pegged through.

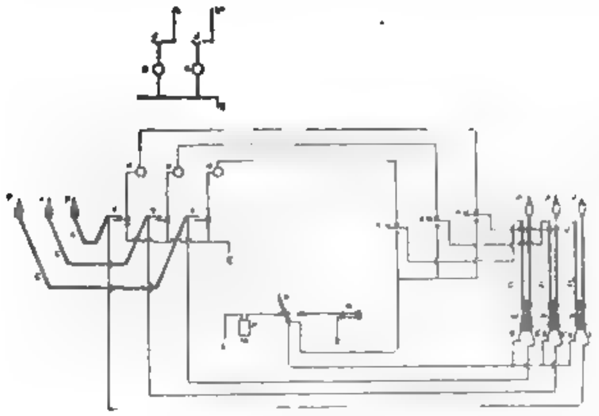


FIG. 10.

The trunk board mechanism is identical with that of the Austrian board just described, with one additional trigger, and is open to the same objections of multiplication both of contacts and labour. An additional ring-off drop is looped in the talking circuit at the trunk board, so that speaking must be carried on through the coils of four electromagnets when a trunk line connects two exchanges worked on this system. If the trunks are of any length, the instruments employed must be exceptionally good to yield even passable results under such circumstances. The third board exhibited is of an altogether different kind, and is the joint invention of Messrs. Fraser and Brown, of the Consolidated Company, although only a modification of the system of multiple switchboards patented in 1889 by Mr. A. R. Bennett, the principal feature of which is the connecting of the multiplied jacks or contacts in parallel instead of in series. Fig. 11 is a plan of the connections for three sections of the Consolidated board. The indicators, A, consist of two circuits differentially wound, one being permanently joined to earth and the other to the contact socket, S^1, and its multiplies on the other sections, which contact sockets are normally insulated from the earth. The circuits are connected so that an in-coming current drops the shutter, while an out-going current splits between the circuits and produces no effect.

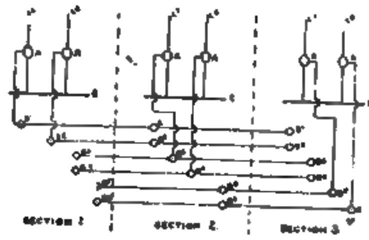


FIG. 11.

When two lines are switched together there are consequently two leaks to earth at the exchange through one circuit of each of the indicators concerned, the talking being done through the remaining circuits. The ring-off drops both indicators. A feature of the board is the plug used to answer callers, which contains in its haft a small finger key or switch, by means of which the operator can change from phone to generator with great facility, without the intervention of the usual separate device. The operations are as follows: 1. Plugs into caller and speaks. 2. Plugs into called subscriber and rings. 3. Replaces shutter. 4. Withdraws plugs. 5 and 6. Replaces the two ring-off shutters. The finger switch helps movements 1 and 2 materially. The motions required are consequently only half those wanted for the Austrian board, and might be further reduced. The weak point of the system appears to be the want of a proper engaged test. The inventors have relied on listening by the operator to tell whether a line asked for is already in use on some other section, but this is obviously insufficient, as subscribers do not always talk incessantly while connected.

THE DIRECT-CURRENT DYNAMOS.

Those of us interested in the design and manufacture of dynamos must be gratified to see the excellent machines now being exhibited at the Crystal Palace.

The improvements made during the last 10 years have raised the dynamo to a pitch of efficiency seldom, if ever, met with in other machines. At the time of the first electrical exhibition at the Palace in 1882 the dynamo designer had to rely almost entirely on experimental data. Now, owing to the researches of the Drs. Hopkinson, Messrs. Kapp, Crompton, Esson, and other eminent engineers, the theory of dynamo design has become thoroughly defined, and the mechanical details have been perfected.

The design and manufacture of large dynamos present many peculiar difficulties, in the solution of which German and English engineers have taken a decided lead, but the latter have bestowed more care on the attainment of high efficiency. The machines now on view at the Crystal Palace show us the methods which the several makers have adopted in this direction.

We propose accordingly to consider the dynamos exhibited under the following headings:

1. The methods shown of perfecting the electrical design.

2. The improvements in the mechanical construction.

3. The respective advantages of the various types represented; and

4. We shall give a tabulated list roughly showing the proportions and output of a large number of dynamos.

FIG. 1. FIG. 3.

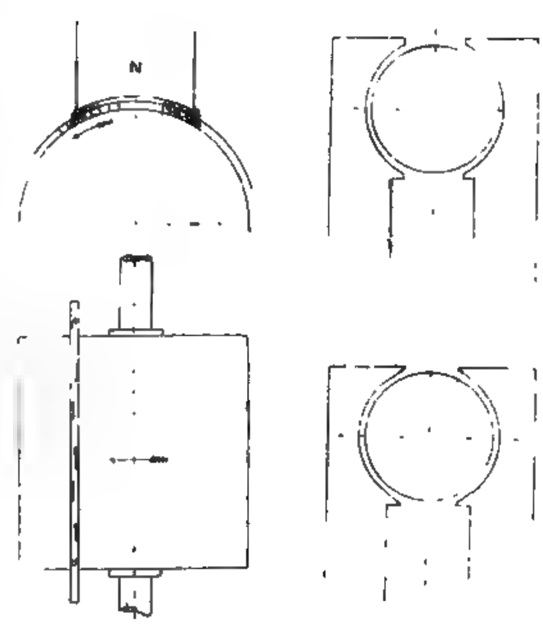


FIG. 2. FIG 4.

Improvements in Electrical Design—Armature Reactions.— Messrs. Esson and Swinburne, in their respective papers read before the Institution of Electrical Engineers in 1890, considered carefully the effects of the back and cross ampere-turns on the armature. The general conclusion arrived at was that large output dynamos should be multipolar.

Bearing out this view, we find that two out of the three largest dynamos at the Palace are multipolar—viz., those made by Messrs. Johnson and Phillips, and Crompton and Co., respectively. We are also informed that the large machines the Electric Construction Corporation are making for the Liverpool Overhead Railway are to be multipolar.

Foucault Currents in the Armature Conductor. — These wasteful eddy currents are produced whenever the induction through a conductor varies. At the edges of the pole-pieces parallel to the axis of the armature, the induction varies rapidly from the maximum value, in the space between the pole and armature core, to zero; consequently when the individual conductors pass this point, they have eddy currents induced in them, Figs. 1 and 2. These increase with the dimensions of the conductor probably as the fourth power of the breadth.

There are three general principles underlying all successful attempts to reduce these losses. The first is that of introducing resistance in the path of the induced currents. The ordinary stranded conductor first used for facility in winding also effected this. Latterly, Mr. R. E. Crompton has introduced the stranded conductor pressed into any desired section. The surface of the wires is first slightly oxidised to increase the resistance between the adjacent wires in the strands. Some makers have used strands in which the wires have a thin cotton covering.

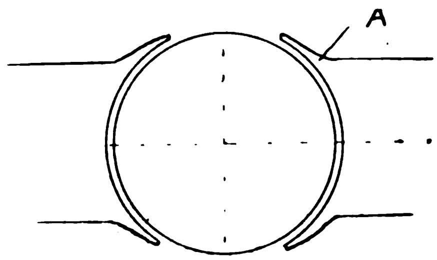


Fig. 5.

The following firms show dynamos with these bars in use—viz., Messrs. Crompton and Co., Limited, Johnson and Phillips, Siemens Bros. and Co., Limited.

The two remaining methods deal with the shape given to the iron parts of the dynamos, and it is curious that the efficacy of the one should be due to an exactly opposite cause to that of the other. In the first the object is to get a slow charge of induction through the conductor, and in the second to make the change extremely rapid. The slow change of induction at the edge of the pole can be obtained by shaping the poles in the following different ways: (*a*) The polar surface is bored out to a slightly larger diameter than required for clearance, and then the poles are brought nearer together, Fig. 3. Thus the distance between the core and the pole increases towards the edge. Messrs. Crompton and Co. show an arc light dynamo with this arrangement of field, but the prevention of Foucault currents is not the primary reason for the

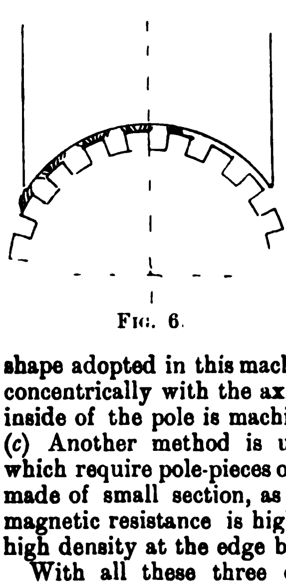


Fig. 6.

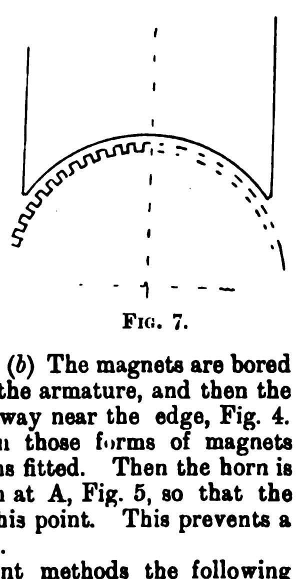


Fig. 7.

shape adopted in this machine. (*b*) The magnets are bored concentrically with the axis of the armature, and then the inside of the pole is machined away near the edge, Fig. 4. (*c*) Another method is used in those forms of magnets which require pole-pieces or horns fitted. Then the horn is made of small section, as shown at A, Fig. 5, so that the magnetic resistance is high at this point. This prevents a high density at the edge beyond.

With all these three different methods the following detail will also help to reduce the loss—*i.e.*, making the edge of the pole not quite parallel to the conductors on the armature. In this way the full effect of the change of induction is never acting on the whole length of a conductor at the same instant, and consequently the maximum E.M.F. producing eddy currents is reduced. The effect of the cross ampere-turns on the armature is to increase the induction at the edge of the polar surface from which the conductors recede, and to weaken the opposite edge. Consequently, to prevent an increase of Foucault currents at full load, the receding edge should be most shaped in accordance with either of the last two methods.

The second principle of making the change of induction extremely rapid is used in the toothed-core armatures made by Messrs. Easton and Anderson, and also by Messrs. Goolden and Co. These armatures are an improvement of the old Pacinotti type. In the early machines of this type the pitch of the teeth in the core was large, to enable a number of wires to be wound in each space, Fig. 6. The fluctuation of induction at the polar surface, due to the distance between the teeth, then produced eddy currents

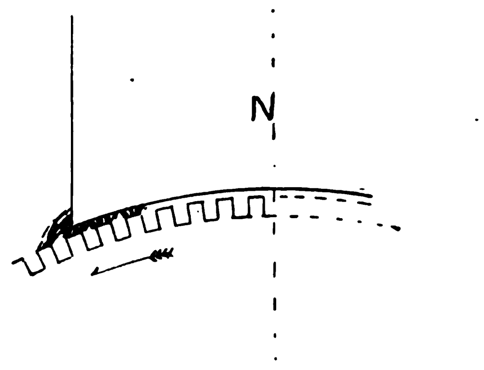


Fig. 8.—Position 1.

in the iron. The loss of power caused by these was so great that toothed armatures were for the time abandoned.

Now the above-named makers use a small pitch, and, as a rule, wind only one conductor in each groove, Fig. 7. It is well to consider the action of the teeth by steps. In the first instance, if the armature were stationary in the position shown in Fig. 7, there would be little or no induction through the conductor on account of the better path offered by the projecting iron teeth. But when the armature has advanced by a distance equal to the pitch, the lines of force have all crossed the spaces filled by the copper. The speed at which they cross the path of high resistance is enormously greater than the circumferential

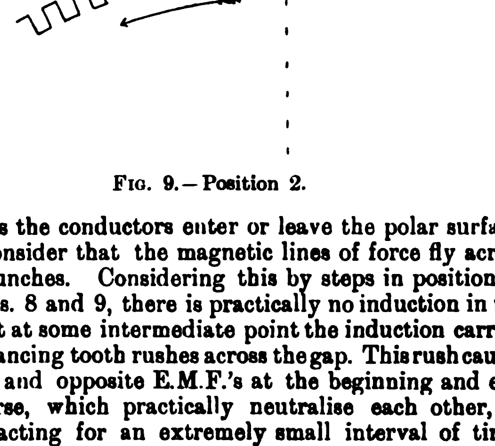


Fig. 9.—Position 2.

speed. As the conductors enter or leave the polar surface, we may consider that the magnetic lines of force fly across them in bunches. Considering this by steps in positions 1 and 2, Figs. 8 and 9, there is practically no induction in the copper, but at some intermediate point the induction carried by the advancing tooth rushes across the gap. This rush causes two equal and opposite E.M.F.'s at the beginning and end of its course, which practically neutralise each other, as are both acting for an extremely small interval of time. The result is that we get a small Foucault loss, and in these recent machines the loss in the poles has been avoided by using a large number of teeth. It is doubtful, however, if the type can be successfully extended to dynamos of large output.

Losses in the Armature Core.—The methods of preventing undue loss of power in the iron cores are now well understood, and the cast-iron armature core kept cool by an internal watercourse is now a relic of the past. The maker of this latter machine had hopes of getting perpetual motion when he saw to what high temperatures his circulating water was raised. The subdivision of the cores to prevent Foucault currents is now carried out by all makers. Many of those exhibiting show armatures unwound, and it is worthy of note that nearly all build up the cores of plates. The Gulcher Company use a thin tape $\frac{3}{16}$in. broad, which must be a decided advantage in the disc type of armature.

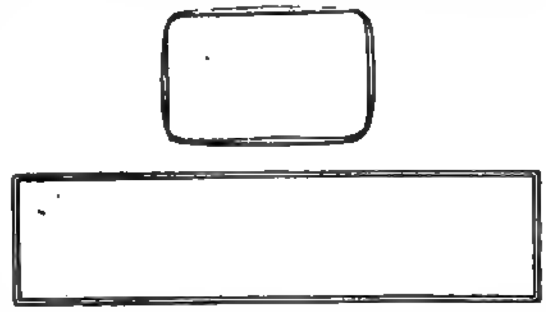
The other cause of heating is due to hysteresis in the iron. In small machines this is not important, although the induction used is high in nearly all designs. With large armatures the section of iron used is increased, and the cooling surface increases only as the two-third power of the volume. The result is that with the same induction the cores get much hotter than those in small dynamos. Another reason against using such high inductions is that the hysteresis loss appreciably reduces the efficiency.

Thus, while in the small machines exhibited, the induction in the core varies between 14,000 and 21,000 C.G.S. lines per square centimetre, in the large dynamos the inductions calculated from the dimensions given to us are as follows:

	C.G.S. unit per sq. centimetre.
Crompton and Co., 130-kw. dynamo	12,500
" " 112-kw. "	13,000
Electric Construction Corporation, 40-kw. motor	15,000
" " 40-kw. motor-generator	15,000
Gulcher and Co., 40-kw. dynamo	12,700
Johnson and Phillips, 130-kw. dynamo	10,600
Siemens Bros. and Co., 216-kw. dynamo	13,000

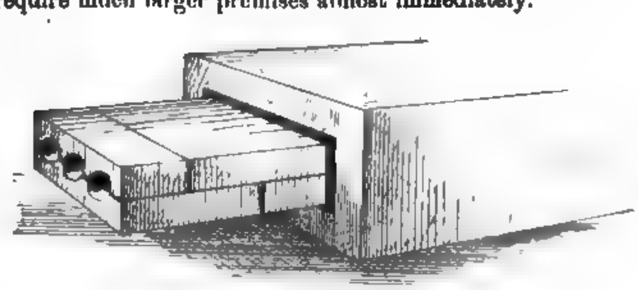
The Crystal Palace Exhibition may be naturally expected to bring before the notice of electrical engineers many improvements in the detail of their work or the apparatus connected therewith. One of these to which we should like to direct particular attention this week is a decided improvement in the containing cells for accumulators, consisting of large glass cells made upon an entirely new process by **Armstrong's Glass Company, Limited,** of Waterloo-street, Birmingham. Before actually describing their exhibits it may be well to mention the state of the present manufacture of glass cells. In the first place, the materials used for accumulator cells are practically limited to lead, ebonite, and glass. Glass is preferable to lead wherever its use is possible for various reasons; principally that glass allows the plates to be thoroughly inspected at all times of charge or discharge, so that no broken or defective plates are left in the cell; and also that glass is a non-conductor of electricity, besides not being attackable by the acid used, as lead eventually may be. Glass cells have therefore long been employed for accumulators, but there are one or two difficulties which stand in the way of their more extensive adoption. The cells, as now made, are very uneven in thickness, have rounded corners, and are irregular on the bottom, due to the method of production employed, which up to the present has been the only one possible. But the great difficulty which stands in the way has been the fact that glass cells actually could not be made by any process larger than about 22in. long. The improvement brought about by Armstrong's Glass Company can be realised to be very great when it is stated that by their newly-introduced process glass cells can be made with perfectly square corners and flat bottoms, the glass being of equal thickness at all parts, and that cells can be made practically of any size desired. At the Exhibition a large glass tank, manufactured on their system, is exhibited which is 4ft. 6in. long. This forms at the present time the largest glass tank in the world, and it serves as containing cell for one of Crompton's central station accumulators. Still larger cells are being made for the same purpose, which will be as much as 7ft. 5in. long. These glass tanks can be used, of course, for all purposes, and the company is engaged in making various shapes and sizes for use in chemical works.

The ordinary process of making glass cells at present consists practically in blowing a large bottle inside a square hot iron mould of the size desired. At first the glass is spherical, but as it touches the sides of the mould the corners only expand. The corners are therefore much thinner than the other parts, and, moreover, are never exactly square. The bottom surface is also usually humped in the middle, due probably to air caught under the glass. This necessitates levelling by means of shaped pieces of wood or other means before the lead accumulator plates will stand evenly.



Armstrong's Glass Tanks.

The Armstrong patent process is very different. A solid iron template of the size desired—the size not being limited—is placed inside a furnace, being previously whitewashed to prevent the glass from sticking. Plates of glass are placed against the four sides and underneath, previously cut to the exact size. The whole is heated up gradually for some hours, and when the glass is at a good red heat a steel oxy-hydrogen blow-pipe apparatus is introduced through working holes in the furnace, and the edges of the glass is brought to a state of incipient fusion. The joint is then rolled by a roller placed at the back of the blow-pipe jet, and a good weld is thus made. All four sides and the bottom are fused together, and the cell left to gradually cool down and anneal. The result is a perfectly square-sided glass tank. Cells made on this method are not more expensive than the ordinary cells; while for large-sized tanks they can be made much cheaper than the competitive tanks made of copper, lead, or other material. These are being made for electroplating pickling tanks and other similar purposes. The patent also provides for the manufacture of large glass tubes or pipes for acid works, and, as can easily be seen, opens out an entirely new field for large glass articles. As an illustration, a tank has recently been built for chemical use, 5ft. high, 6ft. long, and only 1½in. wide—a shape previously quite impossible of manufacture by any known process. Mr. Armstrong's process took quite 500 experiments before the conditions of certain success were accurately determined. The company has works at Albion, West Bromwich, but is expected to require much larger premises almost immediately.



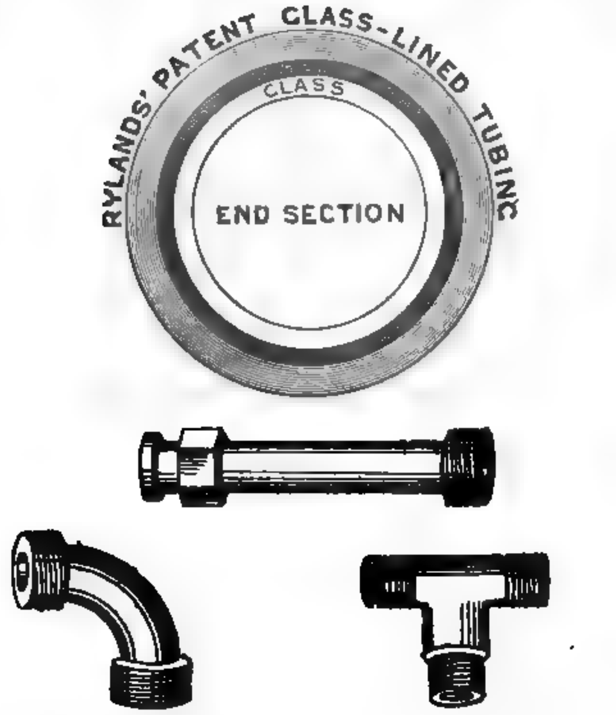
Armstrong's Glass Conduits for Mains

A further invention shown by the same company at the Exhibition consists of solid glass conduits for electric underground mains. Slabs of glass are made in lengths from 1ft. to 5ft., having half-round grooves of 1in. to 2in. diameter, which are bedded in pitch and concrete. The method is new, and has not been yet practically tested, but is offered for any electrical engineer to take up. The process of laying consists in first digging a trench, laying a trough of concrete, on which a layer of soft pitch is run; on this the lower slab is placed, then the upper slab, breaking joint. Both are then run in with pitch, and the concrete trough completed above, thus forming a solid insulating conduit, in which bare copper cable for high or low tension can be drawn. We

are unable to express any opinion as to its electrical qualities in the absence of practical tests, but the conduit is economical to construct, only cheap materials being employed, and the proposed use of bare copper would again reduce the cost of the mains. The illustration shows the arrangement in a sufficiently explanatory manner.

While speaking of glass-lined conduits, we should like to mention the glass-lined iron tubing made by **Dan Rylands, Limited,** of Barnsley, who have an interesting exhibit at the Crystal Palace, showing pipes, large and small, bends, junctions, tees, and so forth, in every variety, all lined with glass. These pipes are exceedingly useful for a variety of purposes, and deserve extended application. For water-pipes they offer less skin friction, and are absolutely clean and healthy. For chemicals they are of course very advantageous, while for the use for which we specially notice them, electric light conduits, they seem to offer distinct advantages.

Rylands's patent glass-lined tubing consists internally of a separate solid glass tube, which is covered and protected by ordinary iron piping—a suitable cement being inserted between the iron and the glass makes the whole a solid structure, and at the same time renders the glass practically unbreakable by ordinary use. Not only has this been accomplished for straight pipes, but by a patent process, of



Rylands' Patent Glass-Lined Tubing.

which Dan Rylands are the sole owners, tee-pieces, bends, elbows, and crosses are similarly manufactured with the glass lining. The tubing is made with either cast or wrought iron exterior piping, and with butt, flange, or socket joints, as desired. By either of these the glass-lined tubing is easily connected together. In every case a thin washer of guttapercha or other packing is interposed to secure a perfectly sealed end before the pipes are screwed up. The glass-lined tubing is claimed as really less expensive than lead piping, and only some 20 per cent. more than iron piping. The severe tests to which the patent tubing has been subjected have proved that it will also stand the extreme alternations of heat and cold. For chemical work in manufactories where acid is to be led about or turned on by tap, the tubing would be invaluable. For electric light mains it is proposed simply to use bare copper wires, thus saving the insulation for long leads, while twin wires could of course be threaded in one pipe for house wiring if desired, with additional security from earth faults.

Amongst other places, the glass-lined tubing has been used in the electric light distribution for the Bridlington Local Board, for carrying the high-tension cables, and the town surveyor and engineer, Mr. R. Railston Brown, considers it has proved itself a valuable conduit for high-tension mains, especially where these mains are unavoidably placed in very exposed situations.

Dan Rylands also make Leclanché jars by patent machinery, and exhibit specimens at their stall. A circular projection is moulded on the bottom of the cell; this serves to receive the bottom of the porous pot and hold it in perpendicular position, not touching the mouth of the cell. Greater accuracy and uniformity is secured in the moulded cells than by hand-made glassware, and specially strong glass is used in the manufacture of these cells.

Amongst the companies using Rylands's glass-lined tubing are the St. James's and Pall Mall Company, Mason's-yard, St. James's; Messrs. Crompton and Co., at Kensington Court; the Blackburn Electric Works, Blackburn, and others.

Among the many interesting exhibits of **Messrs. Laing, Wharton, and Down** to be found in the Entertainment

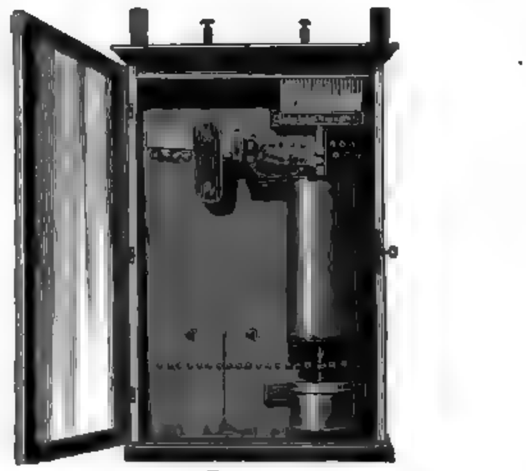


FIG. 1.

Court, is an automatic regulator, which is said to prove exceedingly useful and effective when an installation of incandescent lamps is run by means of prime motors whose speed is very irregular. The action depends upon that of

FIG. 2.

an electromagnet, the core of which, as it moves to and fro, brings in or puts out contacts to which resistances are connected. But the accompanying illustrations explain the whole matter.

Carmarthen.—The price of gas at Carmarthen i 4s. 6d. per thousand, and the contract with the gas company was only renewed by the casting vote of the chairman of the Town Council.

THE

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LANE FOX v. KENSINGTON AND KNIGHTSBRIDGE.

This case, admittedly one of the utmost importance to the electrical industry, has employed the Courts for a period of some sixteen days, and was fruitful with surprises from day to day. Judgment has not yet been delivered, so it is impossible that we should comment upon the various and conflicting evidence given, but we may be permitted, without endangering ourselves for contempt of court, to combat views often somewhat energetically expressed as to the present method of deciding technical cases. One of the suggestions oftenest expressed is that the judge trying such cases ought to be fully equipped with technical knowledge. We respectfully demur to this view, and every trial we listen to proves that men possessed of technical knowledge have their views warped in every direction and could not listen unbiasedly. Their opinions are mostly of a settled and of a dogmatic character. They are not open to conviction, because they start with knowledge. The judge, if imbued with scientific information, would either be orthodox or heretical, and would revel in the subtleties of scientific research, and entirely overlook the broad principles usually underlying every question subject to litigation. It is not long after the opening of a case before the experienced judge begins to see the broad points upon which in the end the issue must rest, and his aim is directed to ascertain the facts which bear upon these points—irrelevant maundering about the importance of some highly attenuated will-o'-the-wisp-like theory is brusquely pushed aside. In the case above mentioned, the Attorney-General referred to the presence of a technical assessor to assist the judge. Where is the use of the assessor? A and B are two celebrated scientific witnesses. They testify on oath to certain things, and their testimony is diametrically opposite. For every assessor who agrees with A, an assessor can be found who agrees with B. It is the duty of the legal advisers of the litigants to see that their case is put so clearly and plainly and truly before the judge that he, possessing a trained experience, may decide the question upon the known scientific facts—if scientific facts are involved—and not upon the fancies which are to be found in the borderland of science. It seems to us that the position of a judge is made difficult, not because of the inherent difficulty of the case, but because he has to decide upon truths which, while they may be truths, are only half-truths. Witnesses are asked questions the answers to which, it is hoped, will make a consecutive narrative of sufficient influence to win the case. They are not asked questions the answers to which may make clear scientific points, if such answers tend to go against their side; and if the opposing counsel happens to ignore in his cross-examination the points which remain half-elucidated, his side has to suffer. The onlooker undoubtedly sees most of the game, and an adverse judgment is as often due to the lack of perception as to the tendency of a half answer by the opposing counsel, as to his having a bad case. There, however, seems to remain a suggestion which possesses some value. In these technical cases, why should not the judge

be able to call witnesses, put to them points which to him are doubtful, or on which the evidence is scientifically conflicting, and let opposing counsel cross-examine in the usual manner? Such witnesses would be uninterested in either party, and would not be answering with reservation to benefit one side or the other. Again, in some cases an honest experiment by a disinterested witness would settle disputed facts once and for all, and would save time, money, and temper. When ten men say a horse is black, and ten as strongly assert it is grey, a man not colourblind will end the dispute by using his eyes.

KEEP OUTSIDE.

During the season it is not uncommon to find an awning over the pathway, and a carpet laid down to the front door, so that invited guests can gain their carriages without danger to skirts. The door is open, but only to the invited. The latter view seems to hold good with the meetings of the Gulcher Company. The shareholders may enter, but the Press has to keep outside. Usually when directors are so anxious to hide their light under a bushel, it means that the light is as difficult to find as the pea under the thimble. Last Monday the counsels of the chairman (Mr. D. de Castro) prevailed, and the meeting was held in secret. A similar suggestion at a previous meeting failed to obtain the consent of the shareholders, but since then no doubt their education in secret ways has become more advanced. At any rate, the chairman pretended, or actually thought, that what he had to say concerning his trip to the Antipodes, and the results to be expected therefrom, had better not become public property. We do not believe that Mr. D. de Castro can give us any news about probable business that cannot be easily obtained elsewhere. We do not believe that any person, or body of persons, in the places he has visited would in any shape or form confide secretly in the chairman of the Gulcher Company his or their intention to carry out work, or to give orders to any one firm, without making enquires as to prices from other firms. The only reason that could possibly be brought forward for having a meeting of shareholders unreported is that private information as to business prospects might be made known to business competitors. Now if a company is in a good business position its directors do not dilate at the meetings upon business details, and business in hand or under negotiation belongs to the details of office work, and not to meetings of shareholders. If a company, however, is in a bad way—an exceedingly bad way—it is necessary for the directors to keep up the spirits of the shareholders as long as they can, in order that the company may be kept going, and the directors draw their fees. To keep up a good head of spirits, it is customary to dilate at length upon what is going to happen. We do not say that the Gulcher Company is in a bad way. We do say this, however, that Mr. de Castro had nothing of consequence to say that might not as well have been said before reporters as before shareholders. We are bound to warn shareholders that no confidence will ever be placed in the stability of a company whose meetings are held in secret. The public draw one conclusion, and one only—not that business details are in question, but that the position of affairs won't bear investigation.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE MOTOR-TRANSFORMER.

SIR,—I think the motor-transformer should be considered one of the most important exhibits in the Electrical Exhibition at the Crystal Palace, for it is to this machine we must look for the conveyance of direct currents to long distances, and every day shows us that the demand for the direct current in the daytime, to be used in motors for power, is increasing. I should like to know what is the percentage of power absorbed by the counter E.M.F. when in full work. The machine itself appears to be well and solidly built, and the oiling arrangement is simple and good. The automatic switch on the primary of these machines should be made to cut out the secondary circuits also, when they are run in parallel, otherwise one may be found running at the expense of its neighbour. I hope the committee now appointed will make a thorough test of the efficiency of this machine with both light and heavy loads, and publish the results.—Yours, etc., W.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

V.

(Continued from page 207.)

RESISTANCE, *continued.*

Wheatstone's Bridge or Balance.—Perhaps the most usual method of measuring ordinary resistances is to employ one form or other of what is known as a Wheatstone's Bridge. All forms of this device comprise three essential parts: (1) a closed electrical circuit, one portion of which consists of two wires or other conductors, so as to provide at this part two separate paths through which the current will flow; (2) a connecting link, or bridge between two points, one in each of these two paths; and (3) a means of ascertaining whether a current is passing along this connecting link.

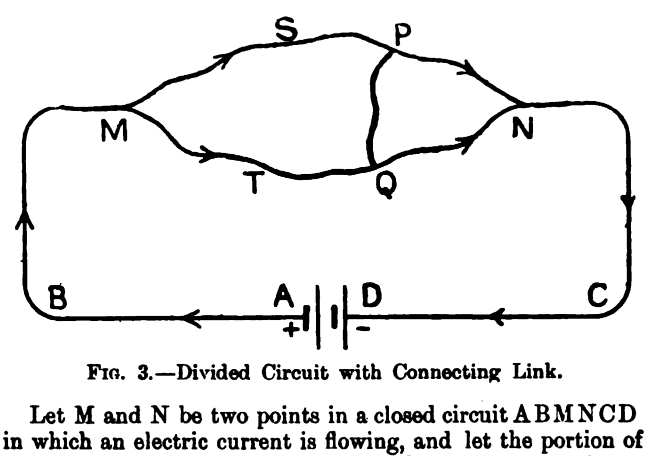


FIG. 3.—Divided Circuit with Connecting Link.

Let M and N be two points in a closed circuit ABMNCD in which an electric current is flowing, and let the portion of the circuit between the two points M and N consist of two paths M S N and M T N. Then the potential or electrical pressure in the circuit falls gradually from A to B, B to M, M to N, N to C, and C to D, so that the potential at B is less than at A, the potential at M is less than at B, the potential at N is less than at M, and so on. We shall confine our attention in the meantime, however, to that portion of the current lying between the points M and N, and which consists of the two paths M S N and M T N. Now if a point P be taken anywhere in the path M S N, its potential must of

necessity be less than that of M and greater than that of N, and furthermore there must be one and only one corresponding point, Q, in the path M T N whose potential is exactly equal to that of P. This is quite independent of the relative quantities of current flowing through the two paths. The total resistance of M S N may bear any ratio whatever to that of M T N without affecting the principle in the slightest degree.

If now the two points P and Q, whose potentials are the same, be joined by a conductor, it is obvious that no current will pass along this conductor in either direction as there is no difference of potential or E.M.F. between its ends; and if a galvanometer forms part of this conductor it will show no deflection.

This connecting link, P Q, forms, as will be seen from Fig. 3, a bridge between the two branches M S N and M T N; and as this arrangement, although originally designed by Mr. Christie, was first made public by Sir Charles Wheatstone, it is usually termed a *Wheatstone's Bridge*. It is also known by the name of *Wheatstone's Balance*, on account of the balancing of the potential *s* at the points P and Q. This connecting link P Q must, however, be more than merely a bridge between M S N and M T N. It must be provided with a current indicator of some kind to show whether any current is passing along the bridge in either direction. This current indicator usually takes the form of a sensitive galvanometer as shown at G, Fig. 4, although in cases where very great accuracy is desired, a telephone, which would give an aural indication, might with advantage be substituted for it.

As a rule, all measurements of resistance by means of the Wheatstone's Bridge method consist simply in determining two points of equal potential or electrical pressure, such as P and Q, one in each of the two arms of a divided circuit, such as M S N and M T N. In the original form of the apparatus, now known as the Metre Bridge, only one of the two points, Q, is fixed, while the other one, P, is moved backwards and forwards along M S N until the balance is obtained. In the form known as the Post Office Wheatstone's Bridge, both the points P and Q are fixed, and the resistance of the arms on either side are altered until the balance is established.

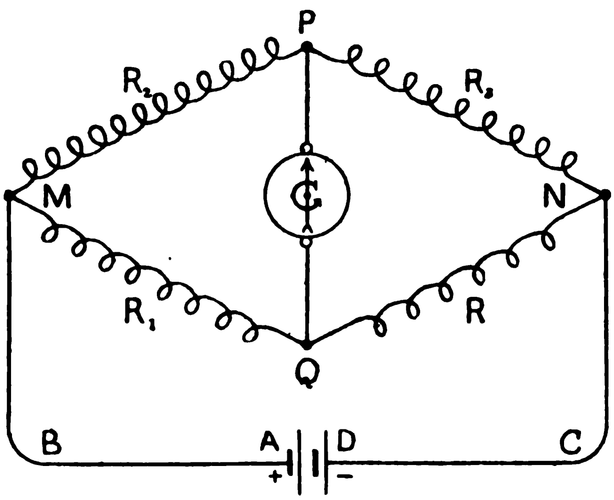


FIG. 4.—Principle of Wheatstone's Bridge.

In Fig. 4, let R_1 R_2 R_3 and R be four resistances connected up as shown, so that R_2 and R_3 together form one branch, while R_1 and R form the other branch of an electrical circuit divided between the two points M and N as before. Let the four resistances, R_1 R_2 R_3 and R, be so adjusted that the galvanometer G, connected up between the two points P and Q as shown on the diagram, gives no deflection. The two points P and Q are therefore at precisely the same potential. But the points M and N are each common to both branches of the divided circuit, therefore the fall of potential from M to P is the same as that from M to Q, and the fall from P to N is the same as that from Q to N. Also since no current is flowing along P Q, whatever current flows through M P the same must also flow through P N, and whatever flows through M Q must also flow through Q N. From this it follows by Ohm's law (which says that the electrical resistance between any two points in a circuit in Ohms, is equal *to the difference of potential* between these two points in Volts, divided by the current flowing in that part of the circuit in Amperes) that P must divide the whole resistance in M P N in the same proportion as Q divides the whole resistance in M Q N. Thus we may write:

$$R_2 : R_3 :: R_1 : R;$$
$$\text{or } R_2 : R_1 :: R_3 : R.$$

Then if the values of R_1 R_2 and R_3 are all known, and the value of R is being determined, we have—

$$R = \frac{R_1 R_3}{R_2}$$

which expression gives the value of R, in terms of three known resistances.

To determine R it is not, however, necessary to know the absolute values of all the three resistances R_1 R_2 and R_3. If the value of R_1 is known, and simply the ratio between R_3 and R_2, we have—

$$R = R_1 \times \frac{R_3}{R_2};$$

this is the condition in the case of the Metre Bridge. Again, if the value of R_3 is known, and the ratio between R_1 and R_2, we may similarly write—

$$R = R_3 \times \frac{R_1}{R_2};$$

this is the condition in the case of the various forms of Post Office Wheatstone's Bridge, Dial Wheatstone's Bridge, etc., where the value of $\frac{R_1}{R_2}$ may be made equal to 100, 10, 1, $\frac{1}{10}$ or $\frac{1}{100}$.

In our next article we hope to deal with the various commercial forms of Wheatstone's Bridge.

(To be continued.)

CAMBRIDGE.

THE ELECTRIC LIGHTING QUESTION.

At the last meeting of the Town Council the Electric Lighting Committee presented the following report:

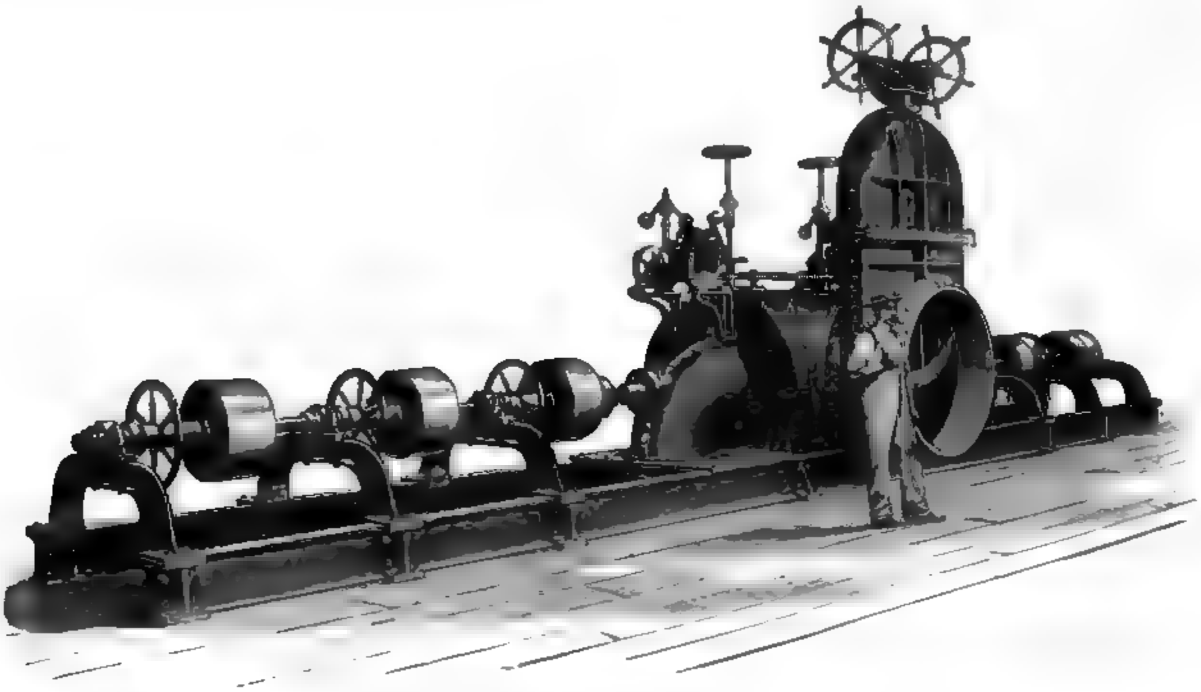
"That in accordance with the resolutions passed at a meeting of the Council held on the 18th ult., the committee entered into negotiations with Messrs. Parsons and Co., relative to their offer to form a company for taking over the powers and duties of the Corporation under the electric lighting provisional order, and received from them the following offer: 'We beg to make the following offer to take over the powers granted to you by the Cambridge electric lighting provisional order. 1. We would undertake to commence the light within the area of supply not later than the commencement of the October term next, if this proposal be accepted at your meeting on the 17th inst., and to proceed continuously with all possible despatch. 2. We will reimburse the Corporation the sum of £1,040 paid by them for the site of the proposed station, which we take over, and also the sum of £300 expended by them in obtaining the provisional order. 3. The system employed would be the alternating current system, with a pressure not exceeding 2,000 volts and transformed down to a pressure not exceeding 100 volts at the point of supply. 4. The Corporation to have power to acquire the undertaking on the terms specified in the Electric Lighting Acts at the end of 32 years, and each subsequent completed period of 10 years. We are advised and believe that to name an earlier period than 32 years would be seriously prejudicial to the success of the undertaking, as it would probably prevent the investment of capital in the concern. 5. The standard price of current to private consumers to be 7d. per Board of Trade unit, such price to rise and fall according to a sliding scale of ¼d. per unit for each 15s. per cent. of cumulative dividend declared above or below 8 per cent. per annum after making due allowance for depreciation and reserve fund. The price not to exceed 8d., and should the directors think desirable, it may be lower than that fixed by the scale. 6. The standard price to be charged to the

Corporation for public lamps to be 5½d. per unit; such price to rise or fall at the rate of ¼d. per unit for each £1 per cent. per annum of cumulative dividend above or below 8 per cent. The price not to exceed 8d.; and should the directors think desirable it may be lower than that fixed by the scale. 7. The Corporation not to consent to the grant of a license or provisional order to any persons or company so long as the supply is sufficiently maintained. 8. We should have full power to form a company, if desired, for the purpose of carrying out the above objects, and the deed of transfer specified in your provisional order should be entered into, if desired, with such company. We should be quite prepared to admit on the board of the company at least three directors resident in Cambridge, and to obtain a large portion of the necessary capital from the town and district. It would also doubtless be found necessary, and we quite agree, to hold a large proportion of the directors' meetings in Cambridge. 9. If entrusted with the powers now vested in the Corporation it would be our endeavour to carry out the work in a manner satisfactory to the Corporation and to the public; and we would with confidence refer to the work done and the results obtained by the Newcastle and District Electric Lighting Company, Limited (of which our Mr. Parsons is the managing director) in testimony of our ability to perform our undertaking.' The committee met on the 8th inst. for the purpose of considering the above offer, Mr. Parsons also being present. In the discussion which ensued, Mr. Parsons consented to the following modifications of the terms contained in the letter of his firm: 1. That the charge per unit should not in any case exceed 7d. 2. That the company should pay £1,000 towards the expenses of the Corporation, instead of the £300 mentioned in their letter. Mr. Parsons, however, was unable to agree to any option to purchase the undertaking at an earlier period than the term of 32 years. A majority of the committee was in favour of accepting the offer contained in the letter of Messrs. Parsons and Co., subject to the two modifications consented to by Mr. Parsons. But he was requested to further consider the question of the option to purchase at the end of seven, 14, and 21 years. The committee met again on the 11th inst., when Mr. Parsons and Mr. Harvey, the solicitor of the firm, also attended. The latter stated that he had again considered the question of the option to purchase, but that he could not advise his clients to consent to any such purchase at the end of seven or fourteen years, on the ground of the difficulty of raising the requisite capital, and that it was essential that there should be some fixity in the tenure of the company, to induce its managers to put their best efforts in the work. He stated, however, that Messrs. Parsons were prepared to consent to the Corporation having the power to acquire the undertaking at the end of 21 years, upon paying for the undertaking as a going concern, including valuation of the goodwill; the amount of the valuation in case of dispute to be settled by arbitration. The committee accepted this proposal, and they further stipulated that the agreement should contain the usual clause against assignment of the undertaking by the company, and such other clauses as should be found necessary or proper to insert in a contract of that nature, which was also accepted on behalf of the firm. Your committee consider the terms so provisionally concluded to be fair and reasonable, and they recommend that the same be adopted by the Council, and that the town clerk be instructed to prepare an agreement in accordance with the provisions contained in the provisional order relative to the transfer of the powers of the Corporation under the order, and, if necessary, to take the advice of counsel thereon."

After a considerable discussion the report was adopted.

TURBINES FOR CENTRAL STATIONS.

We illustrate herewith a pair of Victor turbines arranged for central station work. The chief feature of this arrangement is the ease with which any dynamo can be thrown in or out of working. This system can be applied, of course, to any number of dynamos desired.



Pair of Victor Turbines for Central Electric Light Station.

The engraving was made from a pair of Victor turbines on horizontal shafts, equipped with Rice's improved disc friction pulleys for driving six dynamos direct from water-wheel shafts. The feeder is provided with a valve gate for shutting out the water in case of necessity. Each turbine is independent, having its own gate rig and governor, and drives three dynamos, either one of which can be cut out at will by means of the friction pulleys, without interfering with the others.

ELECTRIC LIGHT INSTALLATION AT BOLTON TECHNICAL SCHOOL.

The electric light installation for the lighting of the Bolton Technical School which was formally opened on Saturday, March 19th, by Alderman Dobson, has been supplied and erected by Messrs. Ernest Scott and Mountain, Limited, electrical and general engineers, Close Works, Newcastle-on-Tyne, and is very complete.

There are two dynamos of the Tyne compound-wound type, fitted with heavy turned flywheels and fast and loose pulleys, for generating the current—each machine giving an output of

90 amperes at an E.M.F. of 105 volts when running at a speed of 900 revolutions per minute. Both dynamos are provided with sliding bed-plates, with tightening screws and holding-down bolts, enabling the slack of the belt to be taken up.

The power for driving the dynamos is obtained from two 14-h.p. nominal gas engines. Countershafting is arranged so that either engine can drive either dynamo, the power being transmitted by belting. The current from the dynamo is conducted by cables to a main switchboard, which is of a very substantial design, and consists of an enamelled slate base fitted with four of Messrs. Ernest Scott and Mountain's double-pole switches with fusible cut-outs, the switches being arranged to control the lights in the basement, ground floor, first floor, and second floor. Two coupling switches are also fitted on the slate base, arranged so that the dynamos can be coupled in parallel or can be run independently or singly as required. The slate base is fitted into a deep oak frame. An ampere-meter and voltmeter are also fitted on the main switchboard, enabling the current and pressure to be measured.

The total installation consists of about 220 16-c.p. incandescent lamps, the lamps being suspended by flexible pendants from the ceilings in the workshops. Where a concentrated light is required at any particular point the lamps are made to raise and lower, this being found a great advantage for weaving. Enamelled iron or opal shades are fitted to the pendants according to the positions in which they are placed, and in the foundry and patternmaking department wire guards have been provided to prevent any possibility of the lamps being broken.

In the lecture theatre arrangements have also been provided so that the current can be utilised for working the magic lanterns or microscopes, or for demonstrating the uses of electricity either as motive power or for chemical purposes.

The installation has been split up and a large number of switches fitted, so that the current can be economised as much as possible, and generally the arrangements throughout are of a very perfect and complete description.

We may mention that Messrs. Ernest Scott and Mountain, Limited, have recently completed a large installation for the lighting of the printing works of the *Bolton Evening News*, and have also lighted up the Rothwell Hosiery Company's mills at Bolton.

THE TELEPHONE AND THE GOVERNMENT.

On Monday the Postmaster-General, Sir James Fergusson, received a deputation from the London Chamber of Commerce, headed by Sir Albert Rollit, M.P., who, on their behalf, gave effect to the opinions expressed at the meeting of the Chamber, held a few days since and reported in our columns, in favour of giving every facility to the telephone industry, and of the introduction by the Government of a Bill for affording facilities for its development. Mr. Sidney Morse further asked that the telephone companies might be regulated by the Board of Trade, as were those connected with electric lighting. The Postmaster-General referred the deputation to a statement he was about to make in the House of Commons on the introduction of the New Telephone Company's Bill, which it would not be respectful to the House that he should anticipate. This statement was made on the following day (Tuesday), when Sir James Fergusson moved the rejection of the above Bill. The National Company's Bill not being before the House, it was not included in the motion. Briefly, these were his points: The New Company sought powers trenching on the Post Office's prerogatives, for Courts had decided that telephones were telegraphs. Hitherto licenses had been granted to companies with the idea of fostering competition and benefitting the public. Amalgamation by the National of all licensees, except the New Company, had defeated this object. Competition had ceased, and inadequate telephonic service was complained of. The form of the license and its restrictions might have had something to do with the small progress made by the telephone in this kingdom. He had, therefore, endeavoured to frame a scheme which would facilitate instead of restricting the spread of the telephone, while sufficiently guarding the Post Office monopoly. That there was real danger of the telegraphs being injured by telephones, unless precautions were taken, was proved by the fact that wherever the telephone system had developed much, as in Lancashire and Yorkshire, the growth of the telegraphs had been checked. The concessions which might be made to the telephone companies were in the main as follow: Telephone messages might be communicated to the telegraph, so as to facilitate through communication between different towns. Messages from a subscriber to a telephone exchange might be delivered to his correspondent; they might be sent by post as letters, or forwarded by express messengers. No charge should be made by the Post Office for the work of taking down telephonic messages and despatching them by telegraph or post. The way-leaves now charged for telephone wires passing over roads or railways might be reduced from £1 per mile yearly to a nominal sum. Lastly, the companies might be allowed, where practicable, to establish call offices in the post offices. Other possible concessions might be made, but they were matters of detail. It was an essential feature of his scheme that the Government should have possession of the trunk wires—that was to say, the wires connecting different towns and those connecting two or more telephone exchanges in the same town; not those between the exchanges and the private addresses of subscribers. The Government proposed to consider the local authorities throughout in carrying out this scheme. The Government further considered that a license should not grant power to do telephone work all over the country. Accordingly, fresh licenses would only be given to bodies operating in certain areas, provided they were supported by the local authority and possessed sufficient capital. In a few days he would move for leave to bring in a Bill on the subject. The debate was then adjourned to next Tuesday.

PHYSICAL SOCIETY.—Feb. 26, 1892.

Prof. W. E. Ayrton, F.R.S., past-president, in the chair.

Prof. S. P. Thompson, F.R.S., read a paper "**On Modes of Representing Electromotive Forces and Currents in Diagrams.**" The author said he had found it advantageous in some cases to depart from the usual methods of representation, and he now brought the subject before the society in order to have it discussed and improvements suggested. To indicate the directions of currents in wires seen end-on, Mr. Swinburne had used circles with and without crosses, but no symbol had been suggested for wires not conveying currents. He (Prof. Thompson) thought the plain circle should be used for inactive wires. A circle with a dot in the middle could then be used to indicate that a current was flowing towards the observer, and a circle with a cross in it to represent a wire conveying a current away. These meanings could be recalled by considering the direction indicated by an arrow, the dot showing the tip of the arrow, and the cross the feathers. Some methods of distinguishing between E.M.F. and current was required. For this he proposed to use thin-stemmed arrows with feathers for E.M.F.'s, and thick-stemmed ones without tails for currents. In the case of electrical transmission of energy this convention had the important advantage that where the two arrows had the same direction energy was being given to the system, and where the arrows were opposite energy was leaving it. Mr. Maycock, he said, had recently published a simple rule for finding the direction of magnetic force due to a current of known direction in a wire. Grasp the wire with the right hand, the thumb pointing in the direction of the current, the fingers will then encircle the wire in the direction of the magnetic force. Dr. Fleming's well-known rule for induced currents was also a right-hand rule, but as it referred to the direction of currents another rule was necessary when considering motors. By making the rule refer only to E.M.F.'s, only one rule was required for generators and motors. For alternating currents the author found it convenient to draw polar curves analagous to Zeuner's valve diagrams. Suppose a line, O P (Fig. 1), representing the maximum value of an E.M.F. or current whose magnitude is a sine function of the time, to revolve at uniform velocity about O, the intercepts O Q, O Q^1, etc., cut off by circles O Q B, O Q^1 D, will represent the magnitudes at the times corresponding to the positions O P and O P^1. The effect of lag can also

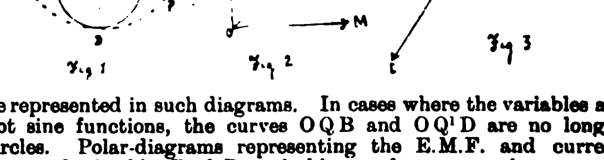


Fig. 1 Fig. 2 Fig. 3

be represented in such diagrams. In cases where the variables are not sine functions, the curves O Q B and O Q^1 D are no longer circles. Polar-diagrams representing the E.M.F. and current curves obtained by Prof. Ryan in his transformer experiments were exhibited, and a working diagram illustrating the changes in three-phase currents was shown. To show the directions of induced E.M.F.'s in diagrams of dynamos and motors, diagonal shading of the pole faces was sometimes convenient; the lines over north poles being drawn from left to right downwards in the direction of the middle stroke of the letter N, and those over south poles from left to right upwards. A conductor passing over a north pole from left to right would have an E.M.F. induced in a downward direction, as indicated by the slope of the diagonal lines. This method of representation was used to show the ways of connecting up multipolar drum armatures, the winding being supposed cut along a generating line, unwrapped from the core, and laid out flat in the manner adopted by Fritsche. In connection with armatures, the author said a formula had been published by means of which the nature of a winding, consisting of a given number of convolutions, and to be used with a given number of poles, could be predetermined. This, he thought, would be very useful in practice.

Prof. Ayrton, referring to the mnemonic character of the modes

of representation described by Dr. Thompson, suggested that the symbols in the author's book should be more mnemonic. He himself was in the habit of using large letters for currents and small ones for resistances: A and a for the armature, S and s for series, and Z and z for the shunt, currents and resistances respectively, and σ and ζ for the series and shunt terms. He also found the following E.M.F. rule very convenient. Draw three rectangular axes O M, O F, and O E, as shown in Fig. 2. If then O F represents the direction of the force (magnetic), O M that of the motion, then O E shows the direction of the induced E.M.F.

Dr. Thompson, in replying, said he thought Mr. Blakesley had misunderstood what had been said, for no ambiguity existed. In describing the windings of armatures, difficulty arose from want of proper names for the various elements, and in his forthcoming work suitable names had been given. To Prof. Ayrton he pointed out that in his book, he (Dr. Thompson) had used mnemonic characters, for r_a, r_s, and r_m, represented the resistances of armature, shunt, and series magnet coils respectively The symbol I for current had also been recommended for adoption by the Frankfort Committee. He objected to Greek letters except for specific quantities, such as angles, specific inductive capacities, refractive indices, etc. He appreciated the simplicity of Prof. Ayrton's E.M.F. rule, but thought it would be better to rotate O E and O F through a right angle about O M, thus giving Fig. 3.

COAST COMMUNICATION PAST AND PRESENT.

A paper on this most necessary and urgent want of the day was read last Friday evening by Mr. H. Beneat, C.E., at the weekly meeting of the Balloon Society at St. James's Hall, Piccadilly. In the unavoidable absence of Rear-Admiral Mayne, C.B., M.P., the chair was taken by Mr. R. Kaye Gray.

Mr. Beneat said that all the islands, rock lighthouses, and lightships should be in connection with the mainland at points as near as practicable to coastguard and lifeboat stations, these stations in turn being in continuous telephonic communication with one another and adjacent postal telegraphic offices. Quoting from articles recently published in the *Times*, he gave some graphic descriptions of wrecks which had occurred, and of two on the Welsh coast—one in 1883, the other in December last—lack of communication in the first instance causing the loss of 18 lives, and in the second the loss of the ship. Speaking of what had been done in the past towards establishing signal stations on our coasts, he gave brief accounts of the experiments with the "Brisk" at the entrance of the English Channel in 1870, and the trial of the telegraph cable to the "Sunk" lightship off Harwich, commenced in 1884 and abandoned a few years ago. He showed that one attempt had been made in the direction of connecting up lighthouses. That of the Fastnet in 1884, which, after several interruptions and expensive repairs to the cable, was abandoned in the third year of the installation. He considered the conditions favourable there to the safe existence of a cable, once properly protected from the force of the sea. He pointed out that something beyond an experimental state had been reached. Although much had been said, but little had been done towards arriving at a comprehensive system of communication with outlying stations. In referring to Lundy Island, and the recent experiences of H M.S. "Banterer" in that locality, he said it would be necessary to lay the cable clear of the tide-race, which was the cause of its frequent failure.

Coming to the present, he dealt with the connecting-up for Lloyd's Tory Island on the N.W. of Ireland with the mainland of Pollaquill Bay in July, 1890, and showed that the cable had been an unqualified success, having worked without interruption since opening a year and eight months ago. This station, commanding, as it does, the route through the North Channel, with shipping property valued at about 35 millions per annum, and about 250,000 passengers and crews passing through annually (according to Mr. James McNeill, of Londonderry) demonstrated the great importance of this point as a signal station. He drew attention to Tory Island being the only outlying station on the coast of the United Kingdom in communication with the mainland, and contrasted this communication unfavourably with the 157 miles of telephonic lines in existence on the coast of Jutland, in the kingdom of Denmark, connecting together 50 lifeboat and rocket stations. He considered that the War Office should take an interest in coast communication. as in time of war it would be invaluable, and that all wires should be subterranean.

Coming to the consideration of what could be done, and how to do it, he suggested that a committee be formed of outside experts, engineers, and mariners. He said that preliminary trials might be made of connecting up certain groups of lightships, also certain lighthouses with the coast. In continuing, he touched upon various methods which might be brought into use for protecting the cables from the action of the sea in connection with lighthouses, and a plan he thought might prove feasible for establishing communication with lightships.

After a short discussion, it was proposed by Mr. E. J. Hobbes, seconded by Mr. C. J. Leslie, and adopted unanimously: "That, with a view to the better prevention of loss of life and property in cases of vessels in distress or shipwrecked, and to give the earliest possible information to lifeboat authorities and rocket apparatus stations, it is desirable that a complete system of telephonic and telegraphic communication should be provided by Government round the coast of the United Kingdom; that the coastguard and signal stations be also connected; and that on those parts of the coast where such stations do not exist, the postal telegraphic offices nearest to the lifeboat stations be telephonically and telegraphically connected therewith."

LOAD DIAGRAMS OF ELECTRIC TRAMWAYS, AND THE COST OF ELECTRIC TRACTION.*

BY A. RECKENZAUN, MEMBER.

In the present paper I propose to draw attention to two important branches of this rapidly-growing subject, "electric traction." These branches relate to the energy consumed in propelling electric cars, and the commercial results of several tramways in different parts of the world.

Of the errors into which the pioneers in electric traction fell, none was more serious, and I may say more general, than that of providing insufficient motive power. The early motors were all too small, too lightly built, and consequently were not durable. In spur gearing, the double-reduction gear has been abandoned by the principal American firms on account of its great cost of maintenance; the high speed at which the motor pinion had to run was detrimental to the life of the mechanism. A reaction has set in, and attempts are being made to drive cars by placing the armatures directly upon the axle. It is questionable whether this method will prove successful in the long run. But the single-reduction gear—that is to say, one pinion and one spur wheel running at moderate speeds—appears to give excellent results, and the repair bills have been largely reduced in consequence.

If we calculate from the accepted coefficients of resistance to traction on common tram rails, we find that an ordinary tramcar will require but 3 h.p. to 4 h.p. for its propulsion when once in motion. But it is the setting of a vehicle in motion from a state of rest which demands the greatest amount of energy, and the electric motors which were built in the early days were soon knocked to pieces by the enormous strain put upon them on starting. On English tramways, it has been computed, a tramcar has to stop from four to eight times every mile, according to the amount of passenger traffic. With a view of ascertaining the exact conditions as to the variations in the power consumed on an electric car, I made a series of tests four years ago with an electric car in the public streets of Philadelphia. Fig. 1 represents a portion of a diagram obtained from careful readings with reliable instruments. The whole trip lasted 71 minutes, but the diagram, Fig. 1, represents only the first 19 minutes. Readings were taken and recorded every three seconds. The maximum current, it will be observed, reached at times 120 amperes. This occurred when starting on curves and gradients. Frequently it dropped to zero, and, in fact, these gaps, representing periods when no current was used, gave, on being added up, 45 per cent. of the total. The car contained 84 storage cells weighing 3,400lb., and it carried an average of 26 passengers. The aggregate weight propelled was seven tons. The distance covered during the entire journey was seven miles, giving a mean speed of only six miles per hour, and this had to be maintained on account of the horse cars which ran on the same line. Averaging the current consumed, we find it to be 31 amperes. The maximum E.M.F. was 160 volts, and the mean 157 volts, giving an average of 6·52 e.h.p. used by the car motor. The maximum current of 120 amperes into the minimum E.M.F. of 140 volts would give 22·5 e.h.p., but this occurred only nine times during the journey, and each time but for a second or two. Currents of from 60 to 100 amperes were recorded more frequently.

The next three diagrams are exceedingly interesting, as they represent the working of three different systems of electric cars, on an overhead conductor line at Des Moines, U.S.A. These tests were made on the same day, over the same length of track, with the same number of passengers carried, and the same kind of car body. The cars were operated by the same man, and the readings were taken by officials of the tramway company. Fig. 2 was obtained from the car fitted with two 15-h.p. Thomson-Houston motors. The maximum current at any time was 75 amperes, the mean 22·4, dropping at times to zero, while the E.M.F. varied between 360 and 520 volts on a run of 20 miles. Fig. 3 gives the curves from observations on a car propelled over the same distance by means of two 15-h.p. Sprague motors. Here, again, we observe a maximum current of 75 amperes, average 25·95 amperes, with E.M.F.'s varying from 320 to 560 volts at the motor terminals. Tests represented by Fig. 4 gave the following results with two 15-h.p. Westinghouse motors: Maximum current, 95 amperes; mean, 31·3 amperes; maximum E.M.F., 560; minimum, 380.

I could give more diagrams of a similar kind, but these will suffice for the purpose of showing the enormous and remarkably frequent fluctuations of current, and the attendant rise and fall of the energy consumed. With several such cars running on a line with overhead or other conducting medium for the transmission of electricity from the generating station to the moving cars, the peaks would occur at more frequent intervals, filling the great gaps in proportion to the number of cars running simultaneously. Little reliance, however, should be placed upon the possibility of obtaining even a moderately constant load at the generating station From numerous experiments, I have found that it takes about 20 seconds to bring a tramcar from rest to its normal speed; during this period the current drops gradually from its maximum, due to the ohmic resistance of the circuit, to a value corresponding with the load upon the car motor at its normal speed. The stoppages on tram lines with much traffic are so numerous that it will often happen that a large percentage of the cars start simultaneously, when for a moment the engines and dynamos have to exert their utmost power, and before the engine governor has time to act, the current may be down again at, or below, its normal.

* Paper read before the Institution of Electrical Engineers, March 24, 1892.

I am indebted to Mr. Gibson Carey, of the Thomson-Houston Company, for the diagram, Fig. 5, which represents the fluctuations of the load at the generating station of the Roundhay electric tramway at Leeds. Five cars were simultaneously on the line, yet the current dropped to zero 20 times within the space of one hour. These abrupt changes have the effect of reducing the average efficiency of the whole system to a comparatively low figure. The engine and dynamo must be able to furnish the maximum energy demanded at any instant, whilst the mean power in many cases scarcely comes to one-third of the maximum. Measurements made by Dr. Louis Bell on several American electric tramways have shown that the efficiency of an entire system, taking the brake horse-power of the car motors, divided by the indicated horse-power of the engine at the generating station, amounts in some cases to only 25 per cent., and that in no case does it reach over 40 per cent. in everyday practice on a tram line. With electric railways having fixed stopping places at long intervals, with the time-tables so arranged that only on rare occasions several trains start simultaneously, a higher efficiency may be aimed at.

Electric light engineers will look with amazement, and perhaps envy, upon the variations in the voltage marked on Figs. 2, 3, and 4. But these are exceptionally great fluctuations, and there are many electric tramways where the volts do not vary more than 15 per cent. A sudden call for large currents always lowers the potential, and this is partly due to the feeders being proportioned to the average output, and partly to the momentary slowing down of the engine. When the governor begins to act, the excess load has very often already disappeared, and then there is a tendency to racing for the next moment, and a simultaneous rise of E.M.F. above the normal. At the City and South London Electric Railway, which is only 3½ miles in length, the deflections on the voltmeter vary between 370 and 500, notwithstanding compound-wound generators, and a regular schedule time of running the trains. Several years ago, I suggested a remedy for equalising to some extent the load upon the generating plant of an electric tramway with overhead conductors, but my suggestion has not been adopted. I advised the use of secondary batteries to act as regulators—not batteries of large capacity, but such as would give a very high discharge rate. Plain lead plates of very large surface, formed on the Planté or any similar process, would certainly add to the smooth working of any railway or tramway where great fluctuations of load are unavoidable, and *compound* winding insufficient. An accumulator of this description could be made very cheaply, and by allowing sufficient material it can be of any durability desired. The diagrams show that the large excess of current is only required for a few seconds at a time, therefore a storage battery of large surface would furnish this in a far more rational way than the best designed dynamo worked by the most delicately governed steam engine. It would save engine power, and reduce the chances of breakdowns due to sudden shocks to the generating plant.

Again reverting to our diagrams, which, to the practised eye, reveal a number of interesting points, we find that on starting a single car from 20 e.h.p. to 50 e.h.p. are absorbed, and this occurs just when the motor is giving a comparatively small mechanical power at its minimum efficiency; this energy is absorbed in producing the initial statical pull, which must be created by many ampere-turns. Now, in order to get many ampere-turns without excessive currents, I designed, some eight years ago, a switch which throws the motors in series when starting, and in parallel, when two or more motors are used, when a sufficient E.M.F. is created by virtue of a certain speed. I also subdivided the field-magnet coils, in order to obtain several graduations and regulate the fields to the requirements of the load and speed. Up to that time electric engineers used idle resistances for varying the speed and power. Mr. Sprague and others have adopted a similar method of regulation. The Thomson-Houston Company use resistance coils up to a certain point, after which portions of the divided field coils are thrown out of circuit. By a judicious arrangement of field windings to suit the exigencies of a given road, a very fair all-round motor efficiency can be obtained.

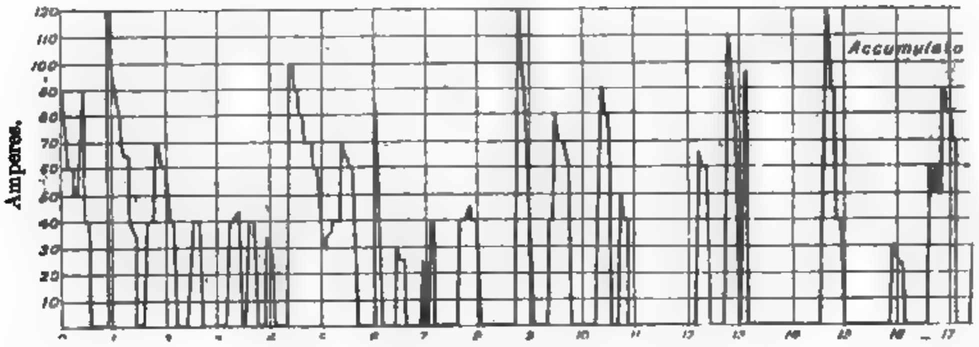


Fig. 1.

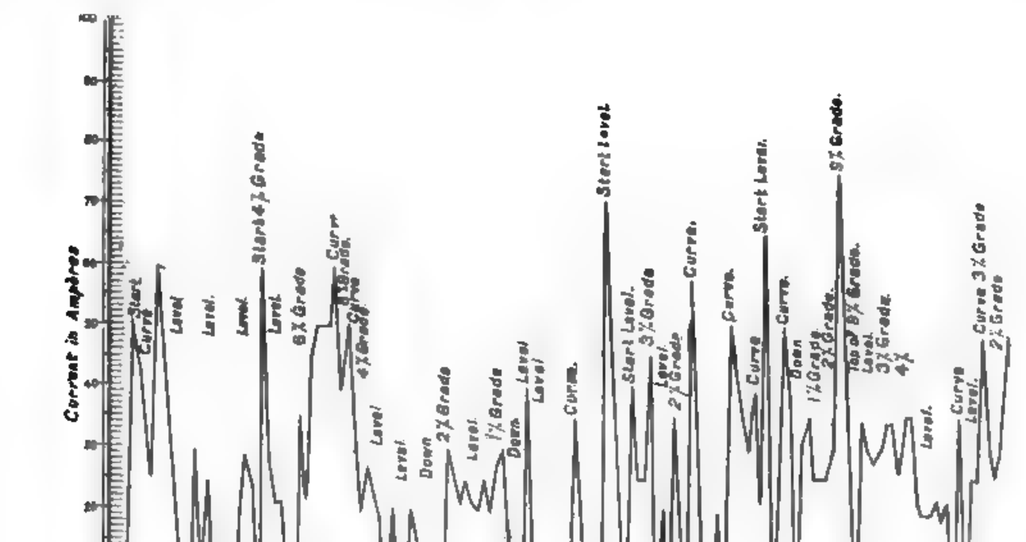


Fig. 2.

The battery car from which diagram Fig. 1 was obtained, required for its propulsion 1·086 electrical horse-power hours per mile run, with an average load of seven tons over a line having no gradient above 4 per cent. The figures obtained by Mr. O. T. Crosby on three American lines with overhead conductors accord with the above very closely. Thus, on the Richmond line the readings were 1·18 horse-power hours per car mile, at Cleveland 0·9, and at Scranton 0·94 horse-power hours. These cars were very much lighter than the one driven by accumulators, but there is a gradient of 9 per cent. at Richmond, and one of 7 per cent. at Scranton, while the Cleveland line is tolerably level; the speeds at Cleveland averaged nine miles per hour, and at the other two lines six miles per hour. The coal consumption measured at the generating stations came out as follows: For the Cleveland line, 8lb. per car mile; and at Scranton, 5·6lb.; that of Richmond could not be ascertained, as the same boilers were used

for both the tram line and the electric lighting plant. On the Frankfort-Offenbach Tramway, and on the Mödling line, near Vienna, both built by Messrs. Siemens and Halske, the coal consumption varies between 7lb. and 8lb. per car mile. Unfortunately, I have not been able to ascertain the evaporative quality of the coal used in these places. Mr. J. S. Badger, in a highly interesting recent communication, relates that the very best station performance he met with in the United States was 1 e.h.p. for 5lb. of slack coal evaporating 7½lb. of water. Writing on the consumption of fuel in general on a number of American tram lines, he found that it varied between 4·3lb. to 12·2lb. per car mile, according to the quality of fuel and the nature of the road and load. Many of the American tramways have recently adopted large cars up to 25ft. in length inside, whereas the usual standard type of car is only 16ft., carrying a proportionately smaller number of passengers, although I have frequently seen 70 passengers occupying a 16ft. car intended to seat 22 people. Overcrowding is not allowed on English tramways.

I have collected a very large amount of material with regard to the all-important question of operating expense, and I am greatly indebted for information given by Mr. Alexander Siemens, Dr. E. Hopkinson, Mr. Holroyd Smith, the Allgemeine Electricitats-Gesellschaft, Mr. J. S. Badger, and Mr. Robert W. Blackwell. Full tabulated statements are appended: to read the same would occupy more time than is at our disposal; moreover, it would add to the monotony of an already very dry paper. With your permission, I will only make such observations regarding each table as may render some assistance to the study of them. Due regard should be taken, in each of the lines, to local conditions. In Germany, for instance, the wages, which form the principal item in the operating costs, are about one-half those paid in the United States. Wages and salaries in England take an intermediate position. Again, the cost of fuel varies in almost every city in the world.

One of the oldest electric tramways in the world is that of Frankfort and Offenbach, in Germany. It was built by Messrs. Siemens and Halske, and opened to the public in April, 1884. Table I. shows the detailed working expenses for the year 1890, giving the sum of 4·608d. per car mile, including all charges. The first financial year—1884-85—gave a much higher figure—namely, 8·256d. per car mile; and it is interesting to note that the working expenses were reduced year after year: this was largely due to improved appliances and the consequent reduction in the maintenance items, as well as in wages. The expenses of the other tramways in the city of Frankfort (which are worked with horses) for the year 1890 amounted to 9·022d. per car mile, or nearly double that of the electric line. The slotted-tube overhead-conductor system is used here, and the entire rolling-stock consists of only 14 cars—10 of which are fitted with electric motors, serving as tow-cars—holding 24 passengers each. About 1,050,000 passengers are carried per annum; this is considered a very low figure, and is partly due to the competition of a local railway. In consequence of this small traffic, the ratio between expenditure and revenue is as high as 70 per cent., notwithstanding the moderate traction costs.

A more recent and equally interesting example of electric tramway enterprise in Germany is that of the city of Halle. The cars on this line were originally drawn by horses, but a year ago the

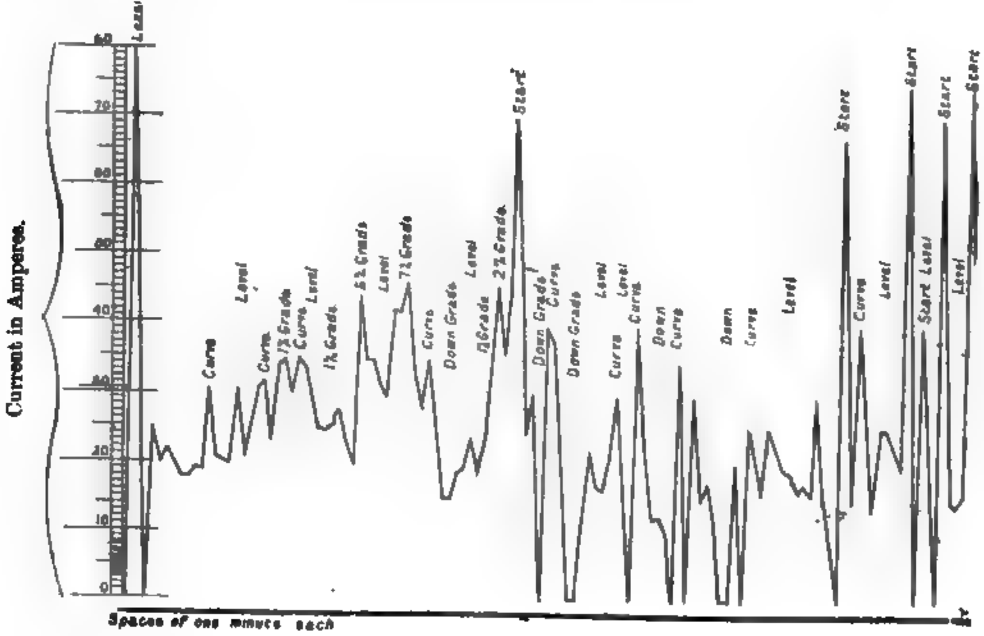


Fig. 3.

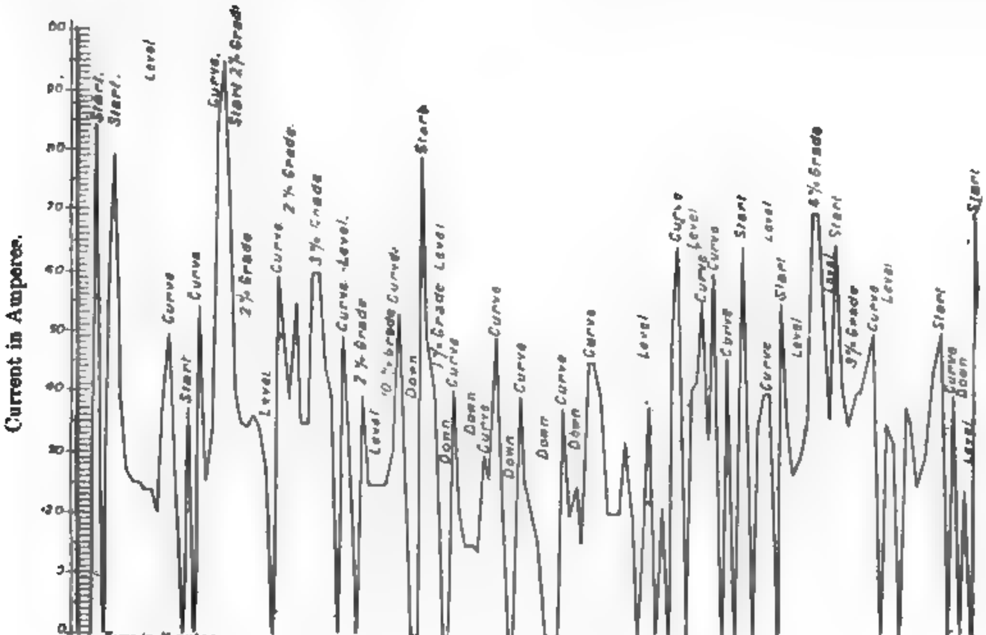


Fig. 4.

municipal authorities gave permission to the Allgemeine Elektricitäts Gesellschaft to erect overhead conductors on the plan adopted by Mr. Sprague in America. I am indebted to Mr. Emil Rathenau for a detailed statement of working expenses ranging over six months—from July 1 until the end of December, 1891. Table II. gives the averages per month and per car mile. The general expenses include taxes, municipal charges, and water rates. The water is obtained from the town supply, the sinking of a well having been found impracticable. The rolling-stock consists of 25 cars; the average number actually running was 20·55. They carry drivers, but no conductors, and this fact renders the wages account remarkably low, the entire working expenses coming to only 2·624d. per car mile, or 54·5 per cent. of the gross revenue. It must be observed, however, that no allowance has been made for depreciation, which, if included, would add nearly another penny per car mile to the expenses account. Incidentally it may here be mentioned that the Imperial German Government stopped the running of the electric cars immediately after the opening ceremony because they interfered with the proper working of the telegraphs and telephones. The case came before the law courts, when the judges decided in favour of the tramway company, stating at the same time that the streets of a city were intended for general traffic, that their course could not be altered, but that the postal authorities could easily arrange the telegraph and telephone wires so that they should not be influenced by the electric lines, which use the rails and earth for the return circuit. The alterations were made, and the tramway has had a good time ever since.

The most remarkable of European electric tramways is that of Budapest, which was constructed by Messrs. Siemens and Halske, of Berlin. A few months ago I visited the Hungarian capital, and I was delighted with the perfect working of the electric cars. Underground conductors are used in this case, and the conduit is immediately underneath one of the tram rails, so that there is no additional slot in the roadway. About 50 electric cars are now in operation over 20 miles of track. The system is exceedingly popular, and it carries a larger number of passengers per mile than the horse tramways. This is probably due to the greater speed, the electric cars being allowed to run 11 miles per hour in some of the streets. I have not been able to obtain detailed working expenses, but I have been informed that the same never exceeded 50 per cent. of the revenue since the opening of the line two years ago. The ratio of working expenses and revenue on the horse-car lines at Budapest is 72 per cent. Another among the numerous continental electric tramways is that running between Florence and Fiesole, a distance of 4·5 miles, which was the first continuous steep grade electric line in Europe. The Sprague system is used in this case. Table IV. is prepared from data contained in a recent paper by Mr. C. P. Sheibner, of the Institution of Civil Engineers. The author of this interesting paper gives, under the heading "Motive Power," the sum of the expenses arising through wages at the generating station, wages of car drivers, fuel, water, repairs, etc. These I have divided in my table in order to facilitate references with data obtained from other lines. It would be an excellent thing if all the electric tramways would keep a uniform record of all the details of working expenses, in the manner done by the existing horse tramways under the Board of Trade rules.

Coming now to electric traction enterprises in the United Kingdom, we find in Table III., referring to the Blackpool tramway, that the gross expenses amounted last year to 9·91d. per car mile, or 57·8 per cent. of the gross receipts. This is a most satisfactory result, considering that the winter traffic of the seaside resort is only just sufficient to cover operating costs, and all the profits have to be earned during the holiday seasons. This is the only line in England, and the oldest line in the world, worked with underground conductors in a slotted conduit. The rent charged by the Blackpool Corporation for the use of line forms a considerable item—1·773d. per car mile—in the sum of the working expenses. Directors' fees and secretarial charges also seem to be liberally arranged, making 1·187d. per mile.

On the Bessbrook-Newry tramway, where water power is used for driving the generators, the haulage costs during six months ending December 31, 1890, amounted to 3·97d. per train mile. This includes water rent, rental of building; wages of driver, guard, and dynamo attendant; maintenance and repairs to dynamos and conductor; oil, tallow, and waste. During the period stated the train mileage was 10 400; the number of passengers, 50,800; and goods carried, 8,600 tons.

The Americans, as you are well aware, are far ahead of us in matters relating to tramways; they count their electric roads by hundreds, and their electric cars by thousands. I need not enlarge here upon figures well known to all readers of engineering literature, but I venture to point to recent statistics on working expenses, and especially to those prepared by Mr J. S. Badger for the Street Railway Convention last October when meeting at Pittsburg. Mr. Badger gave an immense amount of data, all systematically arranged, of which Table V. is an abstract, converted into English equivalents as to money values. Those interested in all its details will find a reprint of this elaborate communication in the *Electrical World* of October 31, 1891. Indeed, in order to fully appreciate the data contained in Table V., certain descriptive matter should accompany it, and this deals with the number and sizes of boilers, engines, dynamos, the quality and price of coal, condition of road and track, sizes and number of cars, total mileage, and wages in various localities. I merely give the most essential ones. Road No. 1 has a generating station containing four boilers, one 250-h.p. Corliss engine, one 150-h.p. Ball engine, one 150-h.p. Brown engine, and two Edison generators. The line runs through five miles of streets, and the steepest gradient is 13·2 per cent., 100ft. long. There are 36 motor cars of the ordinary size, of which 20 are in daily use, making annually 601,966 miles. The price of coal is 8s. 4d. per ton, and the consumption 7lb. per car mile. Road No. 2: Four boilers, two Taylor-Beck engines of 125 h.p. each, one of 175 h.p., one Armington and Sims of 250 h.p.; five Edison dynamos. Track, six miles long; steepest gradient, 9·25 per cent. for 400ft.; 18 motor cars, of which 16 are in daily use, making an annual mileage of 724,000. Price of coal, 7s. 3d. per ton; consumption, 11lb. per car mile. Road No. 3: Eight boilers; nine steam engines, of which five are of 125 h.p. and two 100 h.p., all of the Phœnix type; also two 125-h.p. Beck engines. Nine Edison and seven Thomson-Houston dynamos supply current for 50 motor cars in daily use, making an average of 1,819,000 miles per annum. There are altogether 53 motor cars, of which four were supplied by Westinghouse, 20 by Edison, and 29 by the Thomson-Houston Company. Steepest grade, 8 per cent. for 800ft.; total length of streets traversed, 35 miles. Cost of coal, 11s. 2d.; and the consumption of fuel is calculated to be 12·2lb. per car mile. Road No. 4: Two boilers and three 150-h.p. Ball engines, driving six dynamos. Length of streets run through, 14 miles, with 18 motor cars, making annually 700,000 miles. There is one steep gradient of 10 per cent. rise for 775ft. Coal in this case costs 8s. 9d., and the amount used per car mile is only 6·4lb. The fifth road, out of seven given by Mr. Badger, is only four miles long, with five passenger cars and one freight car. It has

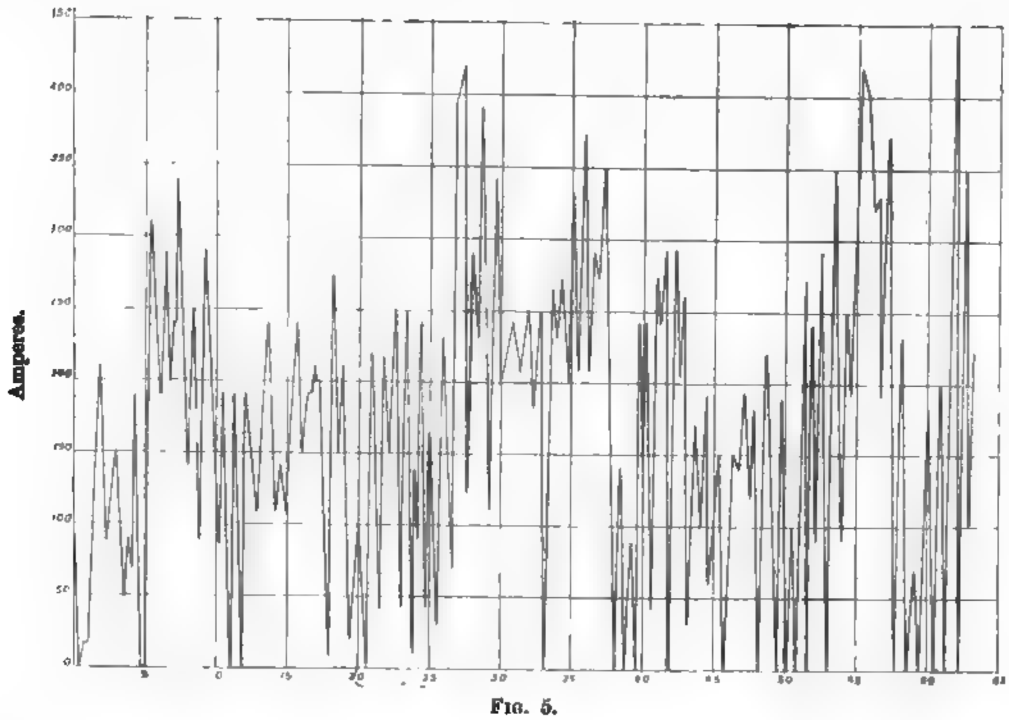


Fig. 5.

only been running for nine months up to the date of the report. The coal costs 12s. 8d. to 15s. 10d. per ton; water 5d. per 1,000 gallons. The wages on all the above lines varied between 40s. and 60s. per week for drivers, conductors, and mechanics.

The most important of all the American electric tramways is that of the West End Railway Company of Boston, where they have now 400 electric cars in operation. Table VI. gives a comparative statement of gross receipts and working expenses of the electric cars and horse cars in the city of Boston for five months ending August, 1891. No detailed account is given, but the rolling-stock is continually being increased, and the central power station in course of construction will contain engines capable of converting 12,000 h.p. into electrical energy. All the American lines referred to are worked on the overhead conductor principle.

I have intentionally omitted comparisons between electric traction and various modes of mechanical traction, such as cable, steam, and compressed air. Our object in this Institution is to enquire into the merits of systems involving the use of electricity, and to further their extension in every legitimate way, and with this point in view I have endeavoured to collect and bring before you such data as may tend to increase the general interest in one important branch of our profession.

TABLE I.—FRANKFORT-OFFENBACH ELECTRIC TRAMWAYS.

Working Expenses of the Year 1890.

	Pence.
Fuel, per car mile	0·48
Wages of drivers and conductors	0·864
Salaries and wages at the generating station	0·96
Maintenance of machinery	0·576
Maintenance of line and buildings	0·288
Taxes and municipal charges	0·058
Miscellaneous	0·518
Depreciation account	0·864
Total per car mile	4·608

TABLE II.—HALLE ELECTRIC TRAMWAYS.

Working Expenses for Six Months ending Dec., 1891.

Average number of cars running	20·55
Total car miles for six months	266,796
Average number of car miles per month	44,466
" " " " day	1,449·3
Daily average mileage for each day, per car	70·6
Total gross receipts for six months	£5,354. 8s.
Average gross receipts per month	£892. 8s.

Working Expenses.	Pence.
Coal	0·3980
Waste, oil, and cleaning materials	0·1444
Wages and salaries	1·4430
General expenses	0·3930
Life insurances	0·0216
Maintenance of track and overhead conductors	0·0459
" " buildings	0·0036
" " boilers and machinery	0·0120
" " cars	0·1480
" " workshops	0·0148
Total working expenses per car mile	2·6243

TABLE III.—BLACKPOOL ELECTRIC TRAMWAY.

Working Expenses for 1891.

Total number of car miles for one year	98,000
Average car miles per month	8,166·6
Gross receipts for one year	£7,241

	Per car mile. Pence.
Repairing centre channel	0·345
" roadway	0·452
Rent, at 6½ per cent. of cost of line to Corporation	1·773
Repairs of armatures, fittings	0·461
Decorating and plumber's work	0·189
Fire and boiler insurance	0·019
Ground rent	0·125
Wages of drivers, conductors, engineer, ticket clerk, etc.	3·260
Coal, oil, waste, etc.	0·714
Water and gas	0·223
Rates and income tax	0·874
Printing and stationery	0·076
Salaries of directors, secretary, auditors, and clerks	1·187
Compensation for damages	0·016
Miscellaneous	0·197
Total working expenses per car mile	9·911
Ratio of operating expenses	57·8%

TABLE IV.—FLORENCE AND FIESOLE ELECTRIC RAILWAY.

Working Expenditure, based on an Average of 600 Car Kilometres, or 375 Car Miles, per Day.

	Per car mile. Pence.
Traffic—Eleven guards and three inspectors	0·960
Maintenance—Inspector, foreman, and eight men	0·680
Motive power—Wages at generating station	0·386
Ten car drivers	0·898
Fuel, one ton per day at £1. 12s. per ton	1·003
Water, oil, repairs, and sundries	0·513
Depreciation and renewals—Boilers 7 per cent., electric plant 8 per cent., cars 5 per cent., line 1 per cent.	2·080
General charges—Rates and taxes, office, and administration	1·050
Total per car mile	7·570

TABLE V.—WORKING EXPENSES OF FIVE REPRESENTATIVE AMERICAN ELECTRIC TRAMWAYS.

—	No. 1. Per car mile.	No. 2. Per car mile.	No. 3. Per car mile.	No. 4. Per car mile.	No. 5. Per car mile.
Permanent way.	d.	d.	d.	d.	d.
Maintenance of road-bed and track	0·225	0·335	0·475	0·085	0·050
Maintenance of line	0·035	0·075	0·100	0·105	0·030
Maintenance of power plant.					
Repairs of engines and boilers	0·018	0·055		0·013	0·036
Repairs of dynamos	0·008	0·007	0·195	0·013	0·008
Miscellaneous repairs		0·118		0·019	0·004
Cost of power.					
Fuel	0·335	0·483	0·822	0·345	1·073
Wages at generating station	0·296	0·186	0·212	0·196	0·437
Oil and waste	0·032	0·077		0·029	0·109
Water	0·046	0·035	0·102	0·027	0·147
Other supplies	0·005	0·010		—	0·116
Maintenance of rolling-stock.					
Machine shops, and repairs to motors and cars	0·922	0·414	1·503	1·162	0·293
Transportation expenses.					
Wages of conductors and motor men	2·318	1·778	2·236	2·516	1·826
Miscellaneous wages for inspectors, trackmen, and cleaners	0·526	0·159	0·095	0·018	1·234
Accidents to persons and property	0·013	0·053	—	—	0·003
General expenses.					
Insurance	0·766	0·094	0·230	0·036	0·084
Salaries, etc.		0·324		0·272	0·685
Office expenses	0·021	0·014	0·081	—	0·035
Advertising, printing, legal, and miscellaneous expenses	0·035	—	0·094	6·693	0·131
Total expenses per car mile	5·601	4·217	6·145	5·529	6·301

TABLE VI.—WEST END RAILWAY COMPANY OF BOSTON.

Working Expenses for Five Months ending August, 1891.

	Electric Traction.	Horse Traction.
Gross receipts	£29,337 6s.	£78,779 4s.
Track and car expenses	9,030 8	26,729 6
Motive power	5,733 0	23,949 0
Total operating expenses	16,274 2	55,043 4
Miles run	375,474·8	1,093,808·2
Ratio of mileage	25·75%	74·25%
Ratio of operating expenses	55·47%	69·87%
Total expenses per mile run	10·41d.	12·06d.
Gross receipts per mile run	18·76d.	17·26d.

ELECTRO-HARMONIC SOCIETY.

A smoking concert will be held on Friday, April 1, at the St. James's Hall Restaurant (Banquet-room), Regent-street, W., at eight o'clock. Artistes: Mr. H. Lester, Mr. Albert James, Mr. Fred Walker, Mr. R. Hilton; flute, Mr. F. Griffiths; at the piano, Mr. Alfred E. Izard; violins, Mr. W. H. Eayres, Mr. W. Richardson, Mons. Jacques Greebe, Mr. T. E. Gatehouse; humorous, Mr. Fred. Cozens. Musical directors: Mr. T. E. Gatehouse and Mr. Alfred E. Izard. A Broadwood piano will be used.

PROGRAMME—PART I.

Part Song.. "Come, Boys! Drink and Merry be"...H. Marschner.
Messrs. H. Lester, A. James, F. Walker, and R. Hilton.

Flute Solo......... "Ungarische Fantaisie"............... Andersen.
Mr. F. Griffiths.

Old Song ......"The Birds in the Spring"...(Arranged by W. A. Barrett.)
Mr. Albert James.

Concertante for Four Violins ......"Andante"—"Allegro" ....Maurer.
Messrs. Gatehouse, Eayres, Richardson, and Greebe.

Irish Song ...."Four Miles from Tralee"......... ......Lester.
Mr. H. Lester.

Part Song ...."The Sailor's Song"................Hatton.

Humorous Sketch ....
Mr. Fred. Cozens.

PART II.

Part Song ...."The Image of the Rose"............ Reichardt.
Solo, Mr. Albert James.
Flute Solo ... . "Saltarella"..... ....E. German.
Mr. F. Griffiths.
New Song ...."Kings of the Road"............... F. Bevan.
Mr. R Hilton.
Variation for Four Violins ...."Carnaval de Venise" ....Dancla.
Messrs. Gatehouse, Eayres, Richardson, and Greebe.
Part Song ...."King Canute".. ... Sir S. A. Macfarren.
Duett - Flute and Piano......"Sonata".. ....Handel.
Messrs. F. Griffiths and A. Izard.
Humorous Selection ....
Mr. Fred. Cozens.

COMPANIES' MEETINGS.

DIRECT SPANISH TELEGRAPH COMPANY.

The ordinary general meeting of this Company was held on Tuesday at Winchester House, Sir James Anderson, chairman, presiding.

In moving the adoption of the report, the **Chairman** reminded shareholders, with reference to the decrease of £2,214 in the traffic receipts as compared with those for the December half of 1890, that he had at previous meetings foreshadowed some such result as inevitable if the tariff were further diminished. He did not know of any authentic instance of a reduction of tariff leading to an increase of revenue until several years of commercial growth had elapsed. In fact, it was an axiom in telegraphy that all reductions of tariff must result in a loss at the beginning. Naturally, however, if they reduced the tariff they broadened the basis from which telegraphy might grow, and they might in most cases gradually recoup their loss in a few years, always provided that the reduction had been sufficient to give a substantial impulse. The halfpenny per word, however, which had been taken from this Company's proportion of 2½d. per word upon their Spanish traffic had simply resulted in a loss of £1,760. A halfpenny per word could have no effect in retarding or increasing external telegraphic traffic. However, they did all they could at the Telegraph Conference, and both our Post Office and the Spanish officials did what they could; but they might hope, now that the result was again shown, that they would not continue to reduce the tariffs, and so make it impossible to maintain submarine cables by private enterprise. All the contingency fund had gone, and £2,376 of their reserve in addition for the purpose of repairing their cables. He might say that he had seldom known of a more fortunate repair than theirs. Their Bilbao cable developed a bad fault at the end of October, and at the end of November—one of their worst winter months—it was repaired in 1,900 fathoms, near the Bay of Biscay. It was totally interrupted for only three days, but, fortunately, the Eastern Telegraph Company had a ship at Lisbon, and did not lose an hour. He had known such repairs to require several months before they could be effected at such a season. They hoped to replace out of future profits the £2,376 which they had taken from the reserve, for the traffic was growing, and the Directors did not bind themselves to pay any given dividend if the traffic should not warrant it. He was trying to believe that the public found that they could not do without the telegraph; and 4d. per word, with a three minutes' transmission to Bilbao and 20 minutes' to Madrid, represented facilities which ought to stimulate traffic if anything could do so.

The motion was seconded by **Mr. Edmund Etlinger** and carried.

COMMERCIAL CABLE COMPANY.

The annual meeting of this Company took place in New York on Monday. The following is a synopsis of the report which was submitted and adopted: The year's earnings amounted to 1,904,717dols., and the working and other expenses for the year amounted to 819,392dols., leaving a balance of 1,085,325dols. Dividends of 1¾ per cent. each were paid for the quarters ending March, June, September, and December, being a total of 7 per cent. on the capital stock of 7,716,000dols., and absorbing 540,120dols. The balance of the year's profit, amounting to 545,204dols., together with 29,796dols. from the profit and loss account of 1890, aggregating 575,000dols., was transferred to the reserve fund. On January 15, 1891, debenture bonds were redeemed to the amount of 600,000dols., and provision was made for the redemption of 600,000dols. of bonds on January 15, 1892.

ELECTRIC CONSTRUCTION CORPORATION.

An extraordinary general meeting of this Corporation was held on Tuesday at Worcester House, Walbrook, when the resolution passed at the last meeting, for increasing the capital of the Company to £750,000 by the creation of 25,000 new shares of £10 each (*vide Electrical Engineer* for the 11th inst.), was confirmed. A resolution was also passed to the effect that the increased capital should be issued in the form of preference shares, entitling the holders thereof to a cumulative dividend at the rate of 7 per cent. per annum on the amounted credited as paid up thereon in priority to any dividend on the ordinary and founders' shares of the Company. It was stated on behalf of the Directors that they did not propose to issue the whole amount at once, and believed that their present requirements would be met by £75 000 at the most.

COMPANIES' REPORTS.

LONDON ELECTRIC SUPPLY CORPORATION.

The following report of the Directors and of the Engineer to the Corporation for the year 1891 will be submitted to the fifth ordinary general meeting of the proprietors, to be held at Cannon-street Hotel this (Friday) morning.

Directors' Report.—The engineer's report appended hereto describes in detail the general position of the works. The result of the year's working was adversely affected by the fire which took place at the Grosvenor distributing station on the 15th November, 1890, which caused an entire cessation of the lighting for a space of three months. After supply was resumed on the 16th February, 1891, it was found that many of the Corporation's old customers had resorted to other companies. Although a considerable amount of new business has been gradually acquired, it was only towards the end of the year that the number of lights installed equalled those connected at the time of the fire. Advantage was taken of this interruption to business to reorganise the system of distribution. The whole of the overhead cables were removed and concentric underground cables substituted; at the same time the distributing mains were extended to many districts in the authorised area of supply which had not previously been touched, and where there is good prospect of remunerative business being obtained. The extension of electric lighting generally has been less rapid than was anticipated, but the light is undoubtedly growing in public favour. The greatly improved supply now given by the Corporation gives reason for anticipating a material increase of business during the current year. As referred to in the engineer's report, measures are being taken by which the cost of producing the current will be very materially diminished, and the efficiency of the generating plant increased. During the year the engagement of Mr. de Ferranti has ceased by effluxion of time. Mr. P. W. D'Alton, the chief assistant to Mr. de Ferranti during the construction of the generating station, has been appointed chief engineer. The Directors retiring, as provided by the articles of association, are Mr. James Staats Forbes and the Honourable Reginald Brougham, both of whom are eligible for re-election. The auditors, Messrs. Kemp, Ford, and Co., who retire in accordance with the articles of association, offer themselves for re-election.

Engineer's Report.—At the commencement of the year 1891, owing to the fire at the Grosvenor station in November, 1890, when much of your transformer plant and other apparatus was destroyed or seriously damaged, your central station at Deptford was supplying no current. When supply was resumed on February 16, 1891, only 9,000 lights were at once installed, and the number gradually increased to 36,000 by the end of the year. In the interval the two dynamos, each of 625 h.p., were removed from the Grosvenor station and erected at Deptford, with two new tandem compound horizontal engines. Until August last these dynamos furnished the supply unassisted, the current, generated at 2,400 volts, being transformed up to 10,000 volts, and at that pressure transmitted to the distributing stations in London. The two dynamos, each of 1,250 h.p., which, prior to November, 1890, had supplied current direct to the mains at a pressure of 5,000 volts, were, during the latter end of 1890 and the early part of last year, altered to generate current at 10,000 volts. An unsuccessful attempt to run one of them was made towards the end of July, but they were not ready for work until the 10th of August, about which time I took over the duties of engineer-in-chief. Since then all these machines have been in work, the larger ones generating current at 10,000 volts. During the past autumn considerable difficulties were experienced in working the 10,000-volt system, and there were occasional failures of the dynamos, high-tension transformers, and trunk mains, many of which were due to the present arrangements for working the machines in parallel. Unfortunately these failures have caused interruption of supply on several occasions, but measures have been, or are now being taken by which it is believed these difficulties will be overcome. For the last four months there has been great improvement, and breakdowns have been of very rare occurrence. A number of faults occurred in the trunk mains during the year, but they are now causing us less trouble and anxiety. I am of opinion that such faults are more or less inseparable from any new system, and that they will eventually be eliminated. During the first four months after the resumption of supply the failures were numerous; during a second similar period they diminished to less than half, and latterly they have been gradually ceasing. Similar troubles were experienced with the high-tension transformers, but as the year advanced the failures became less frequent, owing to careful repairs, and during the last four months we have had but one failure. A few months since we established at Deptford a new department, where we repair transformers and make various parts of machines for maintenance and renewals. The work already turned out by the department is equal to anything we have had done by outside contractors, and superior to most of the work supplied to us; at the same time a considerable saving in money is effected, and work is more promptly done. The work on the 10,000-h.p. dynamos was suspended in May last by your order, but the parts of the machines have been properly protected and are in good condition. The distributing mains have been greatly extended during the past year, and, as there are now upwards of 27 miles laid, a large increase in the volume of business may reasonably be anticipated. They are in a thorough state of efficiency, and have caused but little expense for maintenance or repair. The permanent switching gear is now being erected at the distributing stations, and will

shortly be completed. At two of the stations it is already in use, and is working satisfactorily. The engines and boilers have been kept in good working order. The two sets of generating plant of 625 h.p. cannot be worked to their full capacity owing to faulty design, in consequence of which it is impossible to produce a larger output than 8,500 to 9,000 lights from each. This defect is about to be remedied to a considerable extent at a moderate outlay. A scheme for condensing the exhaust steam has been approved by you, and I am getting forward with the preparations for the work. When completed, which I hope it will be by July next, it will greatly improve the running of the engines, and will have the effect of saving at least 25 per cent. of the consumption of coal

(Signed) P. WALTER D'ALTON, engineer-in-chief.

CAPITAL ACCOUNT FOR YEAR ENDING DECEMBER 31, 1891.

Total Expenditure to December 31, 1891.

Dr.		£ s. d.
Expenditure to December 31, 1891	£648,476 1 0	
Less depreciation	306 3 10	
	£648,169 17 2	
Buildings, freehold land, and general construction account at Deptford		124,352 6 8
Plant and machinery at Deptford		156,143 12 11
Mains, including the cost of laying		148,096 1 5
Purchase of the business of Sir Coutts Lindsay and Co., Limited, including plant and machinery at Grosvenor station, goodwill, expenses, etc.		248,876 11 4
Transformers		42,482 6 2
Meters		5,827 10 11
Electrical instruments		12,082 8 2
Cost of provisional order		4,900 3 8
Tools		1,210 5 9
Distributing stations		5,669 15 10
Alterations to offices and stores to December 31st, 1891	£3,217 2 3	
Less depreciation	262 12 6	
		2,954 9 9
Office furniture, less depreciation		632 9 1
		753,428 1 8
Balance		44,251 18 4
		£797,680 0 0

Cr.		£ s. d.
Ordinary shares, 111,000 of £5		555,000 0 0
Preference shares, 49,840 of £5, £5 paid	£249,200 0 0	
Less calls in arrear (of which £950 has since been paid)	6,680 0 0	
		242,520 0 0
Forfeited shares		160 0 0
		£797,680 0 0

REVENUE ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1891.

Dr. A.—To Generation of Electricity.		£ s. d.
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing same on the works		4,419 10 11
Oil, waste, water, and engine-room stores		1,161 12 0
Salaries of engineers, superintendents, and officers		660 0 0
Wages and allowances at generating station		2,300 13 11
Repairs and maintenance as follows:		
1. Buildings	£199 2 0	
2. Engines and boilers	404 7 11	
3. Dynamos and exciters	663 10 0	
4. Other machinery and tools	129 13 8	
5. Transformers and accessories	105 8 10	
		1,502 2 5
		10,043 19 3
B.—To Distribution of Electricity.		
Salaries of superintendents and officers	366 10 0	
Wages and allowances to linesmen, fitters, etc.	1,061 3 4	
Repairs, maintenance, and renewals of mains of all classes, including materials, and laying the same; also wayleaves	1,179 8 4	
Repairs, maintenance, and renewals of transformers, meters, switches, fuses, and other apparatus, on consumers' premises	660 7 11	
		3,267 9 7
C.—To Rents, Rates, and Taxes.		
Rents payable	1,436 3 5	
Rates and taxes	1,397 0 10	
		2,833 4 3
D.—To Management Expenses.		
Directors' remuneration	1,374 19 11	
Salaries of secretary, engineers, accountant, clerks, and messengers	3,020 17 7	
Stationery and printing	189 16 2	
General establishment charges	614 3 6	
Auditors	72 3 9	
		5,272 0 11
E.—To Law and Parliamentary Charges.		
Law expenses	626 7 11	
Compensation claims	47 15 5	
		674 3 4
Stores at 31st December, 1890		427 2 3
		£22,517 19 7

Cr	£ s. d.
Sale of current per meter, at 7½d. per B. T. U.	13,782 19 10
Sale of current under contracts	31 1 6
Rental of meters, converters, and other apparatus, on consumers' premises	883 18 9
Sale and repairs of other apparatus	358 19 8
Transfer fees	24 2 6
Running stores on hand at December 31st, 1891	479 15 8
Balance	6,957 1 8
	£22,517 19 7

NET REVENUE ACCOUNT FOR THE TWELVE MONTHS ENDING DECEMBER 31, 1891.

Dr.	£ s. d.
Depreciation on alterations to offices and stores	262 12 6
,, ,, office furniture	43 11 4
Revenue account balance	6,957 1 8
	£7,263 5 6

Cr.	£ s. d.
Balance from last account	813 7 7
Interest on deposits	297 18 10
Balance	6,151 19 1
	£7,263 5 6

RESERVE FUND ACCOUNT.

Dr.	£ s. d.
Allowances made and bad debts written off during 1891	946 18 4
Balance	53 1 8
	£1,000 0 0

Cr.	£ s. d.
Amount provided at December 31, 1890, to meet allowances off accounts, etc.	1,000 0 0
	£1,000 0 0

GENERAL BALANCE-SHEET TO DEC. 31, 1891.

Dr.		£ s. d.
Capital account: Amount received as per account given above		797,680 0 0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc., to 31st December, 1891		5,983 18 11
Sundry creditors on open accounts		8,224 8 1
Bills payable		6,933 17 4
Reserve fund account balance		53 1 8
		£818,875 6 0

Cr.		£ s. d.
Capital account: Amount expended for works as per account given above		753,428 1 8
Cash at bankers—		
Messrs. Coutts and Co.	£1,743 19 6	
Messrs. Glyn, Mills, Currie, and Co	1,065 9 3	
London and County Bank, Deptford	217 14 1	
		3,027 2 10
Cash in hand		43 3 7
Cost of redeeming debentures		30,000 0 0
Preliminary expenses		10,311 3 10
Sundry debtors for current		8,436 3 11
Other debtors		6,997 15 5
Net revenue account		6,151 19 1
Running stores on hand December 31, 1891		479 15 8
		£818,875 6 0

BUSINESS NOTES.

Removal of Offices.—The offices of the Montevideo Telephone Company, Limited, have been removed to 96, Gresham House, Old Broad-street, E.C.

London Electric Supply Corporation.—The fifth ordinary general meeting of this Company will be held at 12 noon to-day (Friday) at Cannon-street Hotel

Personal.—Messrs. Pritchard and Co., civil engineers, of London and Birmingham, have removed their London offices from 2, Storey's-gate, to Westminster-chambers, 1, Victoria-street, Westminster, S.W.

Brush Company.—With reference to the issue of 4½ per cent. debentures of this Company, as noted in last week's *Electrical Engineer*, we are informed that letters of allotment and regret were posted on Wednesday evening last.

West India and Panama Telegraph Company.—The receipts for the half-month ended March 15 were £2,908, against £2,986 in the corresponding period of last year The November receipts, estimated at £4,642, realised £4,650.

Appointment.—The Brush Electrical Engineering Company has appointed Mr. L. Alwyn, who was till lately engineer in charge of Messrs. Laing, Wharton, and Down's City installation works, to be their sole City agent, at 53, Queen Victoria-street.

City and South London Railway.—The receipts for the week ending 20th March were £897, against £767 for the same period last year, showing an increase of £130. The receipts for last week showed an increase of £21 as compared with those for the week ending March 13.

Boardman's Electric Sun Lamp Patent, Limited.—Registered by C. E. Baker, 22, Great George-street, Westminster, with a capital of £10,000 in £5 shares. Object: to carry on the business of an electric light and power and manufacturing company in all its branches. Registered without articles of association.

Western and Brazilian Telegraph Company.—The receipts for 10 weeks ended March 4 amounted to £33,917, and for the week ended March 11 to £2,872. The Directors have decided to resume the publication of the receipts, which was discontinued in the latter part of last year owing to the fact that the information might be utilised by competing lines.

Mutual Telephone Company.—The business of this Company was taken over by the New Telephone Company on Wednesday last. The business of the exchange will be carried on as usual by the late staff of the Mutual Telephone Company, with Mr. A. R. Bennett as general manager. The March list of subscribers in Manchester already speaking, which will be issued shortly, will contain over 1,100 names

Rockhampton (Queensland).—The report of the Directors of the Rockhampton Gas and Coke Company for the seven months ended December 31 last, which was adopted at the half-yearly meeting of shareholders held on the 4th ult., contains the following: Since the last general meeting of shareholders, the Directors have taken a definite step in the matter of the electric light. After careful consideration it was decided to instruct the Company's London agents to invite applications for the position of electrical engineer to the Company, and out of a large number of applicants Mr. A. E. Neal, formerly of Birmingham, was selected. He has reported on the systems of electric lighting most suitable for Rockhampton. As the early introduction of the electric light will be advantageous to the Company in a variety of ways, the Directors have decided to proceed with it without delay, and have accordingly purchased a quarter of an acre of land in Alma-street, between William and Denham streets, for the erection of the works. Upon the frontage of this site general offices and showrooms will be erected for the convenience of the numerous customers in both sections of the Company's business, and the Directors are strongly of opinion that the removal of the offices to a more central position than the present one will be conducive to an increase of business. The Directors have undertaken to supervise, through the electrical engineer, the electric light operations at the Mount Morgan Gold Mining Company's Works.

Perth Tramways.—The prospectus of the Perth and District Tramways Company, Limited, has been issued asking for a capital of £15,000, divided into 3,000 shares of £5 each, which are now offered for subscription, payable, 10s. per share on application, 10s. per share on allotment, and the balance in calls as may be required. The Directors are: William S. Ferguson, Esq, Pietstonhill, J.P. for the county of Perth; Peter Campbell, Esq., of Lingwood, New Scone; Bailie David Macgregor, Laurel Bank, Perth, J.P.; Robert P. Shields, Esq., manufacturer, Perth; James C. Orchar, Esq. (of Messrs. Robertson and Orchar, engineers, Dundee), Angus Lodge, Broughty Ferry, J.P. for the county of Forfar. Bankers: The Bank of Scotland, Perth, and head offices and branches. Solicitors: R. and J. Robertson and Dempster, Town and County Bank Buildings, Perth. Auditors: J. and R. Morison, accountants, Perth. Secretary, *pro tem.*: John Mackay, New Scone. Registered office: 27, South Methven-street, Perth. The Company has been formed for the purpose of constructing and working tramways in the city of Perth, and between that city and New Scone and other places in the surrounding district. The Company is applying to the Board of Trade for a provisional order for constructing and working on the electric accumulator system tramways from Glasgow-road through Perth to New Scone, and the necessary consents have been obtained therefor. The estimated revenue is £1,901, and expenditure £1,159, leaving a net profit of £742, which, after paying a dividend of 4 per cent., will leave a balance of £142. The estimated cost of construction is £13,500.

PROVISIONAL PATENTS, 1892.

MARCH 14.

4949. **The generation of electricity for electric lighting and other purposes.** Arthur Francis Willman, 1, Avonmore-road, West Kensington, London.

4961. **Improvements in slide resistances for electrical purposes.** Alexander Muirhead, 124, Chancery-lane, London. (Complete specification.)

4988. **Improvements in electric-circuit closers.** Charles Ernest Thomson, 45, Southampton-buildings, London.

4992. **Improvements in insulated electric conductors and means to be employed in their production.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

5002. **Improvements in electrical conductors and means for laying the same.** George Wilkinson, 11, Furnival-street, Holborn, London.

MARCH 15.

5052. **Electrically-driven whipper for eggs, creams, sauces, and the like.** George Davis, 3, Palace-place, Buckingham-gate, London.

5086. **Improvements in electric block signalling apparatus.** William Phillips Hall, 45, Southampton-buildings, London. (Complete specification.)

5096. **Printing telegraphs.** Edward Jennings Silkman, 24, Southampton-buildings, London. (Complete specification.)

MARCH 16.

5141. **Multiple fuses and switch for use in electric circuits.** Charles Scott Snell and Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London.

5186. **Improvements in electric arc lamps.** Ladislas Lenczewski, 46, Lincoln's-inn-fields, London.

MARCH 17.

5245. **Improvements in the production of caustic soda and carbonate of soda by electrolysis, and in apparatus therefor.** James Pedder, 16, Doward-street, Appleton-in-Widnes, Lancashire.

5266. **Improvements in the mechanical construction of dynamo armatures.** Gerald Percival, 30, Old Georges-street, Cork.

5311. **Improvements relating to the construction of electrodes for electrolytic purposes.** James Charles Richardson, 6, Bream's-building, London.

MARCH 18.

5365. **Improvements in joints for electric light fittings.** Munro's Electrical Manufacturing Company, Limited, and James McFarlane, 154, St. Vincent-street, Glasgow.

5380. **An improvement in pendant electroliers for electric lighting.** George William Ready and John Palfreeman, Engineers' Department, Royal Courts of Justice, London.

5383. **Improvements in the means of synchronising alternating-current dynamos and of working them in parallel and taking them out of parallel.** John Augustine Kingdon, 29, Marlborough-hill, London.

5409. **Improvements in secondary batteries.** George Edward Barker Pritchett and Theodore William Pritchett, 31, Soho-square London.

MARCH 19.

5432. **An improved automatic electric security lock.** Edward Daniel Taylor, 65A, Cathnor-road, Goldhawk-road, Shepherd's Bush, London.

5442. **Improvements in galvanic batteries.** James Frederick Bennett and Francis Arnold Colley, Bank-buildings, George-street, Sheffield.

5474. **An improved incandescent arc lamp.** Arthur Hirsch, 57, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1890.

20992. **Electric bells.** Jones.

1891.

4064. **Electricity meters.** Hookham.
4306 **Dynamo-electric generators.** Boggett.
5167 **Making tubes by electrolysis.** F. E. and A. S. Elmore.
5342. **Electrical thermometers.** Callendar.
5947. **Incandescent electric lamps.** Chapman.
6517. **Electric light switches.** Dorman and Smith.
6978. **Dynamo-electric machines.** Boult. (Stone.)
7283. **Telegraphy and telephony.** Bennett.
7331. **Telephonic apparatus.** Abel. (Société Générale des Téléphones.)
8151. **Distributing alternating currents.** Siemens Bros. and Company, Limited. (Siemens and Halske.)
8227. **Electric accumulators.** Thompson. (Tudor.)
10451. **Electric light, etc. posts.** Haywood and Driver.

1892.

1391. **Coating articles by electro-deposition.** London Metallurgical Company, Limited, and Cowper Coles.
1396. **Electric circuit breaker.** Eichler.
1484 **Secondary batteries.** Entz and Phillips.
1580. **Electric low-water alarm** Mathews.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3⅜
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	1¼
Swan United	3½	4½
St. James'	—	8⅝
National Telephone	5	4⅜
Electric Construction	10	6
Westminster Electric	—	6¾
Liverpool Electric Supply	5	5
	3	3

NOTES.

The Electro-Harmonic smoking concert takes place to-night.

Edinburgh Exhibition.—The guarantee fund to the amount of £26,084, out of £26,559, has been realised.

Matlock Tramway.—A cable tramway is to be begun at Matlock.

Interurban Telephony.—Telephonic communication between Newcastle and London will be shortly established.

Panama.—Messrs. Siemens, says the *Bulletin International*, are constructing an electric tramway at Panama.

Deputations. — The Mayor and members of the Halifax Corporation visited Bradford electric station last week.

Accumulators.—A paper on "Electric Accumulators" was read last week by Mr. H. M. Waynforth at the Mason College, Birmingham.

Coast Communication.—Sir Ed. Birkbeck has asked for an early day for a debate on electric communication to lightships and lighthouses.

Dover.—The terms of the contract between the Dover Corporation and the Brush Company have been definitely settled, and the agreement drawn up.

Institution.—The discussion of Mr. Reckenzaun's paper on "Load Diagrams of Electric Railways" will be continued before the Institution on Thursday, April 7th.

Leeds Tramways.—A stoppage occurred last week on the Leeds electric tramways owing to a cylinder head being blown out of the engine. The cars were put on next day.

Wandsworth.—The Wandsworth Board of Works have received a communication from the Board of Trade revoking the Wandsworth District Electric Supply Order of 1890.

Chiswick.—As will be seen by their advertisement, the Chiswick Local Board invite tenders for the transfer or lease of the electric lighting powers. Tenders to be sent in by May 4th.

Taunton.—At the Council meeting held to consider the question of purchasing the electric light undertaking, it was decided to have the advice of an expert, at a cost not exceeding 50 guineas.

Crystal Palace Concert.—A very enjoyable smoking concert was held last Friday in the Grand Saloon, Crystal Palace, by the electrical exhibitors. It is proposed to make the concerts a regular feature.

Berlin Electric Railway.—To demonstrate the possibility of using electric traction on the Berlin underground railway, the Allgemeine Company propose to construct a trial line outside the city.

Royal Institution.—The following papers will be given before the Royal Institution. On May 20, J. W. Swan, M.A., on "Electro-Metallurgy"; on June 10, Prof. Dewar, F.R.S., on "Magnetic Properties of Liquid Oxygen."

Rome Tramcars.—Accumulator cars are being tried at Rome, the accumulators being supplied by the Oerlikon Company, of Zurich. The cars are run up to 19 miles an hour, and are charged every second day, doing 47 miles a day.

Kingswood.—At the meeting of the Local Board of Kingswood, near Bristol, Mr. Parfitt, jun., of the firm of Parfitt and Son, Keynsham, who are supplying the electric light, attended undertook to have the main road lighted this week.

Hospital Lighting.—The London hospitals are rapidly adopting the electric light. Among the important medical charities where the light is being used are the Middlesex, Westminster, St. George's, and King's College Hospitals. Others doubtless will follow.

Accrington.—The electric lighting scheme for Accrington shows signs of falling through owing to the lack of interest shown by tradesmen and large consumers of gas. It would appear that the price for the electric light has frightened most of the tradesmen.

Johannesberg.—The Johannesberg branch of Woodhouse and Rawson has carried out the first contract for lighting in that town, have prepared plans and supervised the erection of lighting plant for Pretoria, and has also supplied and erected plant for a number of mining companies.

Giant's Causeway Accident.—At Derry Assizes Mr. and Mrs. Hall, who were injured by jumping from the electric cars at Giant's Causeway from fear of collision with a steam car, claimed £2,000 damages, and were awarded £375, of which Mr. Hall was allowed £15, and the balance went to his wife.

West of England Telephones.—The Western Counties and South Wales telephone wires have suffered extensively in the recent snowstorms, which were very severe in the West of England. Notwithstanding, this 40 miles of new wire have been erected in the Three Towns within the past month.

Lecture on Electricity.—On Thursday evening, 24th inst., before the Dulwich Literary and Scientific Association, a popular lecture, entitled "Electricity and its Uses," was given by Mr. W. Perren Maycock, M.I.E.E., at the Central Hall, Dulwich. Mr. H. J. Powell, B.A., L.C.C., occupied the chair.

Rome.—On the 31st December, 1891, the Anglo-Roman Electric Light Company had a network of primary wires of 20,457 metres, and secondary 4,517 metres. They had in operation 152 transformers and 109 meters. There were 12,713 lamps installed, of which 353 were arcs and 12,360 incandescents, representing a value of 16,827 16-c.p. lamps.

Barnsley.—The Barnsley Lighting Committee have paid a visit to Bradford for the purpose of inspecting the electric light station. Mr. Waddington, at the last meeting of the Town Council, said the committee were as anxious as ever to introduce the electric light. They were acting in the interests of the ratepayers, and would report shortly.

Personal.—Mr. Francis G. Bailey, whom many will know as having been recently engineer in charge of the model electrically-lighted theatre at the Crystal Palace, and other work for Messrs. Siemens Bros. and Co., is now leaving that company to take the post of assistant lecturer and demonstrator under Dr. Oliver Lodge at University College, Liverpool.

Moy Hall.—This Highland home, near Inverness, is being electrically lighted by Mr. A. A. C. Swinton for its proprietor, the Mackintosh of Mackintosh. Water power will be employed to drive the dynamo, the turbine being situated at a distance of about half a mile from the house. The installation will comprise about 160 incandescent lights and a battery of accumulators.

Electric Hoists and Pumps.—Mr. John Ritchie, in a paper before the Scottish Society of Arts, dwelt strongly upon the fact that the electric motor is a highly efficient machine, and is much better adapted and more economical than steam for hoisting purposes. Mr. E. A. Browning similarly advocated the use of electric motors for pumping in collieries. Both papers were well received.

Horticultural Exhibition.—The Brush Electrical Engineering Company, Limited, have contracted for the supply of electric light plant and accessories for the forthcoming International Horticultural Exhibition to be held at Earl's Court. The actual lighting arrangements will be under the control of Mr. A. H. Wood, electrical engineer to the Earl's Court Exhibition Syndicate, Limited.

Long-Distance Telephony—The New York correspondent of the *Western Morning News* telegraphs from New York on Wednesday: "The Bell Telephone Company having completed its arrangements for increasing its capital, has now decided that as soon as this has been subscribed, the work of developing the long-distance system shall be taken in hand and pushed forward with energy."

Rouen.—The central station of Rouen is to be considerably extended, and the new plant will be established in an ancient church which has been purchased by the company. Two 500-h.p. Farcot engines and four dynamos by Heilman and Co., licensees of Mr. C. E. Brown's patents. These are the first Brown dynamos installed in France, and probably the first dynamos in the world erected within the precincts of a church.

Wrexham.—At the monthly meeting of the Wrexham Town Council, Alderman John Jones moved that the town clerk be instructed to write to the electrical company of Wrexham to enquire what price they wanted for their undertaking, as it was desirable in the growing requirements of Wrexham to become possessed of such a property. The Mayor (Mr. Frederic W. Soames) seconded the motion, which was carried.

Subways for London.—We notice that the electric lighting companies are opposing the London County Council's Subways Bill, which is now being considered by a Select Committee of the House of Commons. In this we think they are mistaken. It is a temporising policy, which, in the long run, will probably prove expensive and bad. Subways must sooner or later be adopted on a large scale, and it seems to us the sooner the better.

Stamford.—The Special Committee of the Stamford Corporation for negotiating with the gas company have not recommended the insistance on a clause for the purchase of the gas works, Mr. Bowman remarking that it was doubtful whether it would be wise to recommend any corporation in the present day to purchase gas works; he thought the electric light would have to be first considered. This met with a warm agreement on the part of other members.

Dundee.—Plans for the new electric central station for Dundee have been drawn up by Mr. W. Alexander, the architect for the buildings, and were submitted last Monday to the Works Committee of the Dundee Gas Commissioners. The elevation shows a neat and well-proportioned one-storey stone building with gables. A basement will be used for accumulators, pumps, etc. The front will contain offices, and the engines and dynamos will be placed in an adjacent machinery-house at the back.

Electric Mining.—On Friday last the electric light at the Butterley Company's new colliery, at Kirkby-in-Ashfield, was successfully started by Mr. Colson, engineer of the Electric Power and Traction Company, who have the contract. The lighting at present is confined to the engine-houses, shops, and screens. Cables are being laid down the shaft to light the pit bottom and underground roads. There is also a pumping plant to be worked by electricity in course of erection.

Crystal Palace District.—The Beckenham Local Board have refused the application of the Crystal Palace and District Electric Supply Company for permission to place a transformer sub-station under the roadway at Sydenham-avenue, and have also resolved to consult Prof. Kennedy on the subject of expert supervision of the electric lighting works in the district of Beckenham with a view to the protection of public property, especially with regard to the disturbance of road surfaces.

Bradford Electric Tramway.—Mr. Holroyd Smith is busy perfecting the details of his electric tramway, now experimentally working at Bradford. The cars are only run late at night as yet. The hill with a rise of 1 in 13 to 24, and a curve of 64ft. radius, is the stiffest bit, and has been climbed with a car of 6½ tons. The whole line is stiff. After the curve is a straight run of 1 in 14, then a stretch of 1 in 24, finally slackening to 1 in 60. This in 600 yards is no easy task, and the cars stop and start again on any part.

Smoke Prevention.—A smoke preventer, the invention of Mr. Chris. Andersen, of Leeds, was tested at Neasden last Saturday. It consists of iron conduits laid between the rails, with round spring trap-doors in each length, the smoke being led below the locomotive to a sliding conduit, which opens the traps, and the smoke is sucked away by a Roots blower at a mile distance. The invention acted well, but is costly—£2,000 a mile double track. It is brought forward to enable steam to compete with electric traction on underground railways.

Cable Machinery.—Messrs. Thomas Barraclough and Co., Manchester, with reference to our note on cable machinery, write to say that the cable works at Milan belonging to Messrs. Pirelli and Co. were fitted by them with both indiarubber and guttapercha machinery, also insulating, stranding and coring machines. They also supplied for the Calais works the whole of the cable-sheathing, wire-winding, yarn-winding, and core-serving machines. For the factory in the South of France they are also supplying the larger portion of the machinery.

Chertsey.—The Board of Trade have received a communication from the Chertsey Rural Sanitary Authority respecting the application of the Weybridge Electric Supply Company's proposed extension to Walton-on-Thames, in which the Rural Authority gives its consent on "the assumption that the company will satisfy the Board of Trade that they are in a position to fully and effectually discharge the duties and obligations imposed upon them by the order of July, 1891, which the Authority considers very desirable in the interest of the district should be carried out."

Hoddom Castle.—Mr. Edward Brook, of Hoddom, has taken advantage of the execution of various additions to his Dumfriesshire residence to introduce electric light to Hoddom Castle. The dynamo is driven by a 9-h.p. gas engine, which is supplied with gas made in Mr. Brook's gas works, which are still used in the lighting of some of the places about the Castle. There are in the various rooms 175 Edison-Swan lamps in all. In addition there is a 2,000-c.p. arc lamp arranged on a davit at the top of the tower, which illuminates the courts and grounds of the Castle and can be seen at several miles distance.

Electric Saw-Mill.—An installation of wood-working machinery for Lord Rothschild has just been erected at Tring Park. The plant comprises band saw and circular saw machines for converting logs, deals, etc., as also planing, moulding, mortising, and tenoning machines, the whole of which are driven by electric motors. The machinery has been supplied by Messrs. A. Ransome and Co., of Chelsea, and erected under the superintendence of the resident engineer, Mr. C, Burman Callow. Although isolated machines have been driven by electricity, it is believed

that this is the first complete saw-mill worked under these conditions.

Worcester.—At the meeting of the Worcester Watch Committee on Friday, the subject of electric lighting was brought up for discussion, and it was resolved to instruct the city surveyor to prepare a report on the subject of the surplus water power of the Severn at Diglis Locks, with a view to using it for generating electricity. Mr. W. H. Preece, who is acting as the committee's adviser, the engineer of the Brush Electrical Company, and the surveyor were requested to attend the next meeting of the City Council, when the subject is to be fully discussed. An abstract of the report upon the tenders for Worcester will be found elsewhere.

Manchester Central Station.—The Electric Lighting Committee of the Manchester Corporation have ordered from Messrs. Mather and Platt, of the Salford Iron Works, Manchester, two large dynamos of their Edison-Hopkinson type. These dynamos are for an output of 410 volts, 590 amperes, at a speed not exceeding 400 revolutions per minute. They are shunt-wound, and will have a guaranteed commercial efficiency of 91 per cent. The dynamos will be almost exactly similar to the four large Edison-Hopkinson machines at the central generating station of the City and South London Railway, and will be driven from compound vertical engines by Messrs. Galloways, Limited, with belts.

Certificates.—We are informed by Mr. L. Drugman, manager of the School of Electrical Engineering, Princes street, Hanover-square, that, as the result of the recent examinations held by Mr. Gisbert Kapp for the vellum certificate of the school, the following gentlemen have obtained the said certificate: Messrs. P. W. Burman, W. J. Davy, W. Dickinson, L. Goichot, C. H. Gray, L. Leskovic, S. E. Linsell, and R. A. Smith. The examination consisted of a paper in mechanical engineering, a paper in electrical engineering, a *viva voce* and practical examination, also engineering design done during the term and average of two test examinations. Sixty-six per cent. of the marks were necessary for the obtaining of the certificate.

Knockin.—An installation has just been completed for the Earl of Bradford's estate offices and workshops at Knockin, near Oswestry, Salop, by Mr. Wm. Sillery, of Wrexham. The generating plant is placed in the saw-mill, and consists of a Siemens dynamo driven by countershafting off the main engine and run during the daytime, to charge a set of secondary cells designed and patented by Mr. Sillery last year. The offices and workshops are illuminated by means of 16-c.p. incandescent lamps, and Siemens arc lamps are used for lighting the timber-yard and inside the saw-mill, together with incandescents, the whole giving every satisfaction. The electric light has also been permanently installed in the ballroom attached to the Bradford Hotel, Knockin, to be used for the first time at Easter.

Electric Traction and Cranes.—The adjourned discussion on Mr. Stephen Sellons's paper on "Electric Traction and its Financial Aspect," will take place before the Society of Engineers at Westminster Town Hall on Monday next, April 4, at 7.30 p.m. A paper will afterwards be read on "The Application of Electricity to Hoisting Machinery," by Mr. Reginald Bolton, of which the following is a synopsis: Hoisting and hauling gear—hand power, steam, hydraulic, rope, belt, and shafting—compared with electrical; advantages of electricity; the electromotor and its conditions of adaptation to hoisting machinery; a new system of gearing; the electric winch; safety overloading device; electric travelling crane; comparative tests; description of various electric cranes; first cost; comparative estimate of three systems of distributing power.

Guttaline.—A new preparation for the purpose of replacing indiarubber and guttapercha has been brought out and protected by MM. Worms and Zwierchowski. To a quantity of Manila gum tempered with benzene is added 5 per cent. of Auvergne bitumen, also mixed with benzene. These are thoroughly mixed together by mechanical means and by the hand. By adding 5 per cent. of rosin oil and allowing 48 to 86 hours to pass between each treatment, a product is obtained having all the suppleness, elasticity, solidity, and durability of the best indiarubbers. If the product is too fluid, the addition of 4 per cent. of sulphur dissolved by means of sulphate of carbon will remedy this. The addition of 5 per cent. of indiarubber to this mixture makes an irreproachable compound for certain purposes. The vulcanisation of this product can be carried out in the usual way.

Resistance of the Arc.—Fr. Stengen, in *Wiedemann's Annalen* (vol. 45, p. 33), describes a proof that the supposed back E.M.F. of the arc is non-existent. In the circuit of arc or shunt dynamos a battery of secondary cells is inserted, together with an ammeter and a tangent galvanometer. If the dynamo is short-circuited the field suddenly diminishes, as also the current in the line. At the moment of extinction of the arc the tangent galvanometer shows a marked deflection due to the discharge of the accumulators—this experiment serves to show that the galvanometer is sufficiently delicate to show a back E.M.F. Take away the accumulators, and the galvanometer shows not the slightest current during extinction, whence the author concludes the arc offers resistance, but no back E.M.F. The experiment permits, however, the possibility of a real E.M.F. if of very small capacity of polarisation, and is, therefore, not absolutely conclusive.

Ceylon.—Progress is being made in the work of utilising water power to supply electrical power to Mariawattee factory in Ceylon. A watercourse is now being constructed from the Mahawillaganga, and buildings are being erected for the turbines and dynamos. It is proposed to obtain 200 h.p., 50 h.p. each will be used for the two factories belonging to the company, and 100 h.p. will be available for others in the neighbourhood who may wish to hire power from them. It is estimated that the cost of the installation will be £4,000. The spot at which it has been decided to take the water out of the Mahawillaganga is, curiously enough, states the *Indian Engineer*, the same as that which the Kandyan kings attempted ages ago to take the water, but apparently failed, as their cuttings in the rocks in the river and at its sides are evidence. The water they attempted to secure so long ago will be at last utilised to drive the whole of the machinery at Mariawattee.

Siemens and Halske in America.—A company has been incorporated in America under the name of the Siemens and Halske Electric Company of America, with headquarters at Chicago. The president is O. W. Meysenberg; secretary, A. W. Wright; other directors, Arnold von Siemens, George William von Siemens, and Alexander von Babo; New York representative, George H. Benjamin, 35, Wall-street. The works will be situated near Chicago, and plans are drawn up for a separate town (similar to that of Pullman City, where the cars are built), and the entire concern is to be run on the co-operative plan. The principal feature will be large dynamos and motors of 500 h.p. to 1,000 h.p. for transmission of power, especially multiphase work. Experimental plants of various kinds are to be erected. The manufacture of submarine cables will be taken up on a large scale, and testing instruments will be another specialty. The capital is half a million

dollars, and the factories will be established gradually as work increases.

Brianne Arc Lamp.—M. G. Roux, in *L'Industrie Electrique*, describes a very simple arc lamp lately introduced by M. Brianne. It has only a single solenoid, which sucks up a curved iron piece. This is attached to an arm working a tooth segment, gearing into a drum, which again drives the long ratchet of the carbon-holder, and this single arm both strikes the arc and feeds the carbons. When the lamp is not in use the iron core drops, gives the drum a turn, and keeps the carbons apart. On turning on the current the core is attracted; this brings the carbons together. The solenoid being no longer on short circuit, drops once more, and so strikes the arc, the iron core being held in a position of equilibrium by the shunt current. When the arc lengthens, more current traverses the coil, the core is attracted, and the gearing piece turned, until at a certain point it ceases to gear, and the flywheel turns by gravity one tooth, when the same action recommences. This takes place usually every 20 seconds. The great advantage of this lamp is its extreme simplicity.

Charging Cut-out.—An improved automatic switch cut-out has been introduced by M. Ch. Ferry, and was exhibited to the French Société des Electriciens at a recent meeting. The apparatus has two coils, one in the exciting circuit of the dynamo, and one which at the proper time is energised by the charging current, and aids the former. Two mercury contacts establish connection of dynamo to the accumulator, and these are thrown in when the strength of the charging current rises to normal or just over. The second coil now takes the principal current and maintains contact in spite of the decrease of the exciting current. Everything remains thus as long as the working is normal, but if the engine slackens and the E.M.F. falls below the requisite amount, the contact is drawn out of the mercury by the action of a spring; even if the spring did not act at once, the current now being reversed on the second coil, repulsion occurs, and the contact is broken with but little sparking. The arrangement permits accumulators to be charged with a dynamo of a very variable speed, such as would be the case if driven by natural forces, and it prevents accident in case of stoppage of the dynamo or slackening of speed through slipping of the belt. The apparatus is constructed by M. E. Ducretet, 75, Rue Claude Bernard, Paris. It appears to be a useful and efficient modification of a piece of apparatus already much in use in this country.

Chicago Exhibition.—The Electrical Committee appointed by the Royal Commission for the Chicago Exhibition met on Monday, the 28th inst., when there were present—Mr. Wm. H. Preece, F.R.S. (chairman), Sir Fredk. Abel, K.C.B., D.C.L., D.Sc., F.R.S., Prof. W. Grylls Adams, M.A., D.Sc., F.R.S.; Major-General E. R. Festing, F.R.S., Prof. George Forbes, M.A., F.R.S.; Prof. David E. Hughes, F.R.S.; Prof. John Perry, D.Sc., F.R.S.; Mr. Alexander Siemens, Mr. C. E. Spagnoletti, Major-General C. E. Webber, C.B., Mr. Peter Wm. Willans, Mr. James Wimshurst, with Sir Henry Trueman Wood (secretary to the Royal Commission). The chairman reported that he had received information from Chicago that one of the engineers of the electrical staff of the exhibition was about to be sent over to this country to confer with the committee on the question of arranging for some portion of the exhibition to be lighted by European firms. It was agreed to postpone the consideration of this question pending the arrival of the gentleman in question. The chairman also informed the committee that there was every prospect of the electrical industries of this country being adequately represented. Several of the newest forms of engines and dynamos for electrical installations would be shown, and it was probable also that arrangements would be made for showing a series of rooms, furnished in the English style, and fitted with the most recent applications of the electric light.

Dinner.—The first annual students' dinner of the Electric Standardising, Testing, and Training Institution took place on Wednesday, Lord Castleton being in the chair. Amongst others present were Earl Russell, Dr. Robson Roose, Judge Snagg, Prof. Robinson, Major Waller, Colonel Gouraud, Mr. Robert Hammond, Mr. Harrison, Prof. Fleming, Hon. R. Brougham, Mr. W. H. Massey, Mr. Swinburne, and other well-known electrical engineers. Major Waller, proposing the toast of the evening, "The Institution," dwelt on the need there existed for well-trained young engineers, and on the value of the institution. He spoke of the difficulty of standardising, as no legal standards were yet adopted. Mr. Hammond, in responding, said that the institution was a resuscitation of his old college, and the added purposes were the outcome of a suggestion by Mr. Ferranti. He alluded to the practical training given by reason of the affiliation to electrical companies and firms, and stated the institution was ready to standardise for either companies or customers. Lord Castleton, in proposing "The Students," pointed out the openings which constantly occurred for utilising electrical knowledge in the army, on board ship, and especially in the colonies. The last toast was proposed by Colonel Gouraud, who, in proposing "The Board of Control and the Staff," amused his listeners by telling how Edison, when questioned as to his "genius" replied, "Bosh! all hard work and love of difficulties." The toast was responded to by the chairman and Mr. Harrison, the principal of the institution.

Electric Launches.—On Thursday last, the launch took place of two new electric pleasure-boats by the General Electric Power and Traction Company, from their boatbuilding yard at Chertsey. The first of these, the "Flosshilde," was built for Lord Dysart, who was present with a party of friends for the launching. The christening was carried out in the approved way by Mrs. Dixon, one of the party. The "Flosshilde" is a very handsomely appointed boat, on finer lines than those previously built. She is the largest private pleasure-boat yet built, being 55ft. long and 8ft. in beam, drawing 2ft. 6in. with equipment and full complement of 50 passengers. The boat is built of mahogany and teak, and has promenade deck with seats. The cells are E.P.S. boat type, 15 plates each. One hundred of these will be used, but the boat will carry up to 150 cells. The current required is 40 amperes, which will give a full speed of eight and a half to nine miles an hour. An Immisch motor of 7 h.p. or 8 h.p. drives direct a three-bladed propeller of special design for high speeds, the speed being 800 revolutions per minute. The second boat, christened "Jim" by Mrs. Smith, wife of the secretary of the company, is a smaller pleasure-boat, 25ft. long by 5ft. 6in. beam, 18in. draught, built for Mr. Ed. Wagg, of Maidenhead, who already has one electric boat. The number of cells in this case is 24 only, same type (B 15), and a 3-h.p. Immisch motor drives a high-speed propeller at 800 revolutions, giving a full speed of about 7½ miles an hour, with about half-a-dozen passengers. The boats were designed and the building superintended by Mr. W. R. Edwards, son of a well-known steam launch builder, and now an ardent convert to electricity. The electrical equipment was carried out by Mr. E. J. Wade, electrical engineer to the General Electric Traction Company. After the launch the party visited the charging station at Platts Eyot, at Hampton.

THE CRYSTAL PALACE EXHIBITION.

THE TELEPHONIC EXHIBITS.—III.

The National Telephone Company, Limited, show a large quantity of apparatus, but little or nothing that has not been exhibited before. A modified linesman's set, with magneto ringer, weighing only 10¼lb., so that it can be readily taken up poles and standards, designed by Mr. Davis, the courteous district manager of No. 4 division, who has charge of the exhibit, may perhaps be considered an exception. There are, of course, lighter sets known, but these have ringing arrangements which are only effective for short lines, whereas Mr. Davis's magneto is good for any distance. A portion of the stall is set aside as a switchroom, and contains a testboard fitted with Coleman and Jackson combined test-jacks and lightning-guards, and a non-multiple metallic circuit switchboard for 90 subscribers, and 10 junction lines on Sinclair's adaptation of the single-cord principle. The board, which was constructed by the Telegraph Manufacturing Company, Limited, of Helsby, has a handsome appearance, and so far as workmanship is concerned is a creditable piece of work, but it occupies an abnormal amount of space as compared with its capacity. Its object is stated to be rapidity in switching, those in charge evidently being under the impression that the movements required are fewer than with other systems, but on tracing a connection through all its stages it becomes evident that this view is untenable. The motions are seven in number—viz.: 1. Operator plugs in to answer call. 2. Puts caller's plug into called subscriber's jack. 3. Rings. 4. Takes out speaking plug. 5. Replaces shutter. 6. Removes plug. 7. Replaces ring-off shutter. So the National Company's board is beaten both by the Scribner and the Consolidated Company's multiple boards, which only require six movements, while the Western Electric Company's non-multiple Standard and Scarborough boards, which are very much more compact and simple in construction, require only one movement more, in spite of which they are probably more expeditious in operation, since all their parts are well within reach, which is not the case with the National. The leading idea of the board can be gleaned from Fig. 12. The indicator is in shunt with the plug and spring-jack by the contacts, C C¹. The insertion of a plug disconnects the indicator of one subscriber, leaving that of the other in derived circuit and available as a ring-off. But there is no provision for distinguishing between a ring-off and a ring-through, so that the National Company does not appear to contemplate any steps towards removing the confusion at present prevalent in London through this cause. The spring-jacks are very complicated in construction, each containing six separate parts and four contacts. The indicators are wound to 1,000 ohms, and have two iron-sheathed coils, but as the sheaths are not connected to the cores, the arrangement is not so effective as that of the Western Electric single-coil pattern already described. While it is impossible to understand in what respects the board can be regarded as an improvement on older and simpler forms, its cost is exceedingly high, for it could not be manufactured for much less than £80, or 16s. per line. An imposing-looking exchange fixture or derrick marks the entrance to the company's stall. It is composed of four wrought-iron tubular standards, about 40ft. high, arranged in a 6ft. square. Each standard is made up of two tubes spliced together by ½in. bolts, the lower half being 3¾in. in diameter, and the upper one ½in. less. Forty channel-iron arms, all fixed within some 10ft. of the top, indicate accommodation for 400 wires. As there is no diagonal bracing below the arms, it is to be presumed that the structure has been designed for exhibition only and not for practical use. Certainly the company would be most ill-advised to allow it to be erected on a roof with the idea of carrying anything like 400 wires. The music-room—where, at different hours, tunes played at Croydon, the Lyric Theatre, Manchester, and in the Crystal Palace itself, can be listened to—attracts many visitors. It is not claimed that the arrangements comprise any novelties, and the transmission is not better than at previous exhibitions.

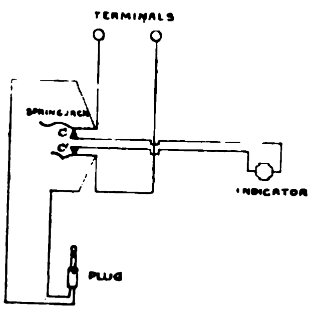


FIG. 12.

The International Electric Company, Limited, agents for Mix and Genest, Berlin, has transferred to the Crystal Palace the greater part of its very complete telephonic exhibit at Frankfort. The productions of the firm are so well known that any detailed notice of them would amount to mere recapitulation. An interesting feature of the exhibit is a stand showing the step-by-step development of the Mix and Genest microphone which, in its perfected form, has become the official transmitter of the German Post Office. An intercommunication system, called the "Selector," in which plugs, flexible cords, and sockets replace the more usual pointer switch, is noteworthy for its simplicity. The connections for four stations can be traced in Fig. 13, in which the instruments are indicated by T, the lines by L, the sockets by S, and the plugs by P. The earth may be replaced by a common return wire if desired. The weak point of the system appears to be want of privacy, since it is plain that conversation between two stations could be overheard by a third designedly or accidentally plugging into the engaged line.

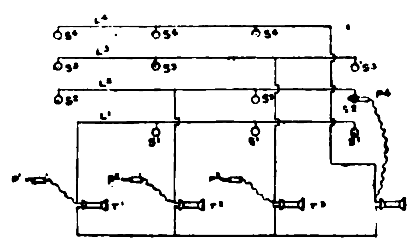


FIG. 13.

In view of the extent to which telephones are now being fitted into signal-cabins and stations by the leading English railways, an ingenious adaptation of telephony to railway requirements, which we are told has already been applied successfully in—of all places in the world!—Spain, is of interest. In the event of breakdown or accident, ability to communicate with the stations on either side of a train is always desirable and sometimes of urgent necessity. Mix and Genest's plan renders it easy of accomplishment. They link the stations and cabins, or some of them, by two wires, one of which is reserved for calling and the other for talking; if there are telegraph wires on the same poles the talking line should be a metallic circuit. A current from some constant form of voltaic battery is kept on the calling wire, and holds attracted the armatures of relays at the stations, between which calls are made by momentarily interrupting the current by suitable contact-breakers. Both the calling and the speaking wires are run down the poles at frequent intervals and respectively led through contact-breakers and spring-jacks, enclosed in weather-proof boxes. The guards on every train are provided with light portable telephone sets which can be slung over the shoulder. In the event of accident a man runs to the nearest pole fitted with apparatus, interrupts the current on the calling wire, thereby releasing the armatures and ringing the bells at the stations or cabins on either side, plugs into the spring-jack on the talking circuit, and immediately finds himself in communication. As the wires are ordinarily used for talking between the stations, they are not likely to be found wanting when an emergency arises. The adoption of some such plan on our English railways would be of most distinct advantage in the interests of both the companies themselves and their passengers, and now the telephone monopoly is at an end

there can be no excuse for lagging behind Spain in such an important matter. The company also shows a 50-line switchboard very similar to the Western Electric Standard board in design, and requiring the same number of movements to operate it.

Messrs. W. T. Glover and Co., of London and Salford, exhibit a variety of telephonic leads and cables, the manufacture of which, ever since the advent of the telephone, has been one of their specialities. Their samples are not merely solid lengths of cable the inside of which may be guessed at and speculated about but not seen, but have ends opened out in fan-shape, so that visitors may not only realise the great number of conductors that it is possible to imprison in a circumference of an inch or so, but inspect the details of covering and construction. Messrs. Glover have adhered to indiarubber, so far, for their telephonic cables, although it is understood that the firm will shortly place on the market cables insulated with a material of considerably lower specific inductive capacity. Specimens of their aerial cables recently made for the Mutual Telephone Company, Limited, are shown. These consist of twisted metallic circuits, varying in number from five to thirty-six, arranged round a central straight wire. The conductors are of No. 20 gauge insulated to 600 megohms. The waterproofing, as in all the firm's aerial cables, consists of double reverse layers of leaden foil, prepared tape, and braiding. Samples of cables made for the National and other telephone companies, adapted both for single and double wires, of the firm's well-known "Magpie" type, the distinguishing feature of which is the ingenious system of numbering and identifying the component wires by means of their black and white covering, are likewise present in great variety. A new description of protective armour for telephone and other cables is being introduced by the firm, and promises well. Being in the form of a sheet-iron tube circumferentially corrugated, it is very strong, and at the same time light and flexible.

The Fowler-Waring Cables Company, Limited, which has recently made a strong bid for telephonic work, exhibits various types of telephone cables insulated with its special material. Noteworthy among them is a cable containing 50 metallic circuits made for the French Ministry of Posts and Telegraphs, and now being laid in the Parisian sewers for use in connection with the telephonic system. The conductors are No. 19 gauge, and the company has guaranteed an insulation of 1,000 megohms and a capacity of ·17 microfarad per mile. A conspicuous feature of the exhibit is a large case containing specimens of the metallic circuit cables manufactured for the Mutual Telephone Company, the conductors of which are No. 20, with an insulation of 600 megohms and a capacity of ·24 microfarad. The National Telephone Company uses Fowler-Waring cables of two specifications, both having No. 18 conductors and being insulated to 1,000 megohms, but varying in capacity, one measuring ·24 and the other ·18 microfarad per mile. A special underground cable made for the British Post Office, and used for connecting subscribers in London to the Paris telephone line, contains only two pairs of twisted conductors, each weighing 200lb. to the mile, and heavily insulated so as to secure a very low capacity. But not content with the excellent results yielded by the Fowler-Waring insulation, the company exhibits specimens of a new dry-core cable it is now manufacturing specially for underground telephone work. Like the Western Electric Company's "dry core," the insulation consists solely of wrappings of non-absorbent paper. The result is certainly remarkable, as the cables from which the specimens exhibited were taken are stated to test as low as ·08 and ·065 microfarad per mile, the conductors being respectively of No. 20 and No. 18 gauge.

The Telegraph Manufacturing Company, Limited, and the **Birmingham Telegraph Factory,** exhibit telephones and accessories in great variety, together with cables, insulators, and ironwork for outside construction, all of good, if familiar, design and workmanship. **Messrs. Woodhouse and Rawson, Limited, Messrs. F. C. Allsop and Co., Mr. Harry Thorpe, The Scientific Alliance,** and several other firms show telephones, switches, and general fittings, but nothing *calling for* special remark.

DIRECT-CURRENT DYNAMOS.—II.

BY R. W. WEEKES, WHIT.SCH.

Improvements in Mechanical Details.

The armatures made 10 years ago were constructed in most cases without regard to the mechanical duties of the various parts. The iron core and the conductor were driven by friction, one general method being to drive conical hubs of wood into each end of the armature when wound. This method was discarded as soon as engineers took up the manufacture, and the driving of the core is now made positive in nearly all dynamos.

The need of a direct drive for the conductor is specially felt as soon as the manufacture of large dynamos is commenced. Messrs. Johnson and Phillips exhibit a striking example of this need in an armature which was run with full load for nine months almost continuously. The conductors in this case are driven by horns, and have been forced by the torque up to them so closely that there is a clear space at the back of each horn, although when first wound the conductors were packed as tightly as possible. If the driving horns had not been used, the conductors would have chafed round the core till the insulation gave out and a short circuit occurred.

Many of the makers do not care to publish full details of their armature construction, but I propose to describe briefly the general methods used to secure the mechanical driving, combined with the necessary provisions for the ventilation of the core. It will be well to consider at the same time the method used for winding the conductors and the end connectors, if any. The Gramme ring armature is now seldom met with in dynamos of an output much about 15 kilowatts, except in special types. The disc type of core is the most general of the exceptions. Arc lighting dynamos giving a high voltage are also usually wound after the Gramme pattern, when the closed conductor circuit is used. This is due to the difficulty of making the end connections in the drum windidg for the large number of turns of wire required.

The sketches given below are diagrammatic, and intended to illustrate the general method used rather than to give the proportions.

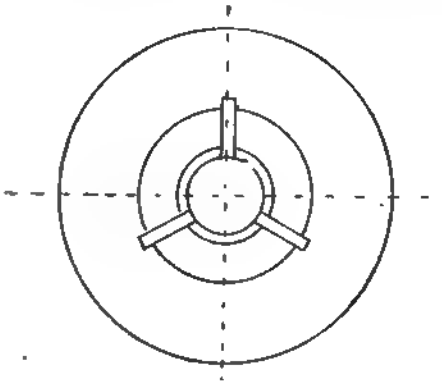
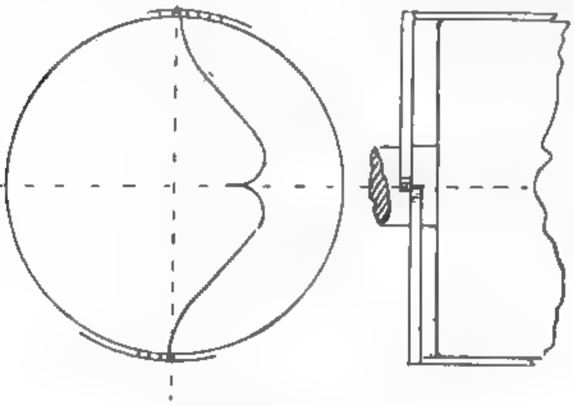


FIG. 10.

Messrs. Crompton and Co. have paid great attention to the direct-driving problem. Their make of core consists of a number of charcoal iron rings, insulated with paper, and driven by means of spider arms keyed on to the shaft and into the iron rings, Fig. 10. At intervals along the length of the core radial spaces are left for ventilation and also for discs of wrought iron. On these there are teeth which form the basis of the driving bars. Strips of insulating material are fastened on either side of each row of these projections, and against these the conductors bed when the driving strain occurs. In the 112-kilowatt armature exhibited on their central stand, there are 12 of these driving bars at intervals round the armature. This at full load allows a mean pull of 230lb. on each driving bar, and a considerable higher maximum pull when the wires are in the strongest part of the field. The connector used by this firm is also on view at the same stall. It consists of a split tape of copper with one arm bent in either direction, Figs. 11 and 12. The result is good as regards the resistance of the armatures, but the connectors somewhat

obstruct the entrance to the ventilating spaces in the core.

The Electric Construction Corporation build up their armature cores of the best charcoal iron plates insulated with paper, and rely on the low induction used to keep the core cool without special means of ventilation. The rings are keyed directly on to the shaft, and compressed together by a brass flange at either end. These flanges have



Figs. 11 and 12.

channels cast on them to carry the connecting wires, Fig. 13. They use wooden pegs driven in the core to drive the conductors. Their most striking exhibit is the 40-unit motor-generator. In this machine there is no need to drive the conductors, as the two systems of winding are interspersed and so drive each other. This also prevents any strain on the bearings of the dynamo. Again, the armature reactions of the two circuits balance each other, so that there is no lead on the brushes at any load.

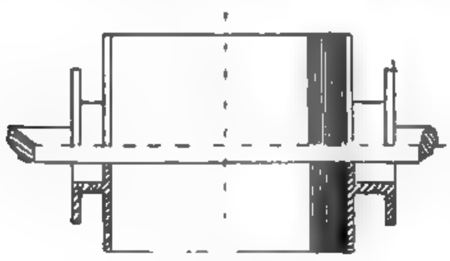


Fig. 13.

Messrs. Easton and Anderson have not given me any details of their machines such as would enable any comparison to be made with those of other manufacturers. The armature core is built up of thin plates in the usual way, but I believe that they are keyed directly on the shaft. The direct driving of the embedded conductors is the best feature of this type of armature, and should make them of great value for rough tramcar work if the weight efficiency of the motor is good. The surfaces of the iron teeth help considerably to keep the armature cool,

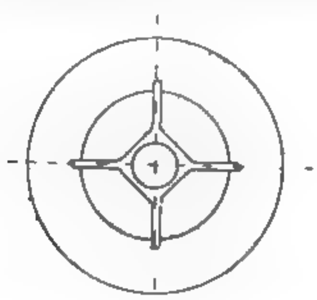


Fig. 14.

but it must be remembered that most of the heat wasted in the copper conductors has to be dissipated from these surfaces as well as that generated by hysteresis. The end connections are carefully protected by a brass casing, which will prevent dust collecting between them.

Messrs. J. H. Holmes and Co. have one of their dynamos on view at Messrs. Browett, Lindley, and Co.'s stall. The armature is Gramme wound, and carefully designed for ventilation. Their method of driving of the core is shown in Fig. 14, and this is the method now generally adopted for machines of this type. The charcoal iron discs are insulated with paper, with thicker fibre rings at intervals.

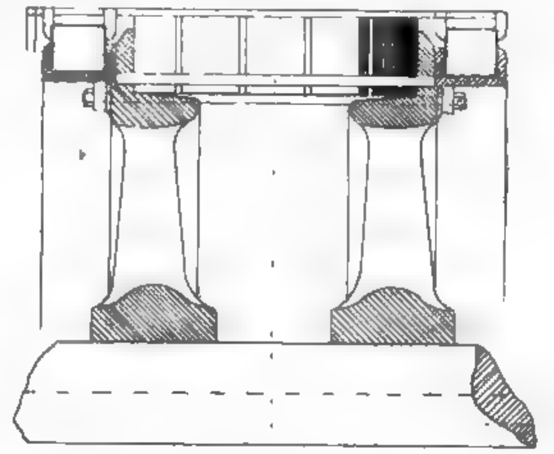


Fig. 15.

The large eight-pole dynamo exhibited by Messrs. Johnson and Phillips has many points of interest. The sketch, Fig. 15, enables the construction to be readily understood. The iron core is built up of charcoal iron plates, punched out to the shape shown, Fig. 16. These have holes in them for the iron bars which hold them together, and forms a good driving connection. The driving frame consists of two strong cast-iron wheels, into which the ends of these iron bars pass. The wheels are clamped together by separate longitudinal bolts, and these also hold on the connection carriages. As shown

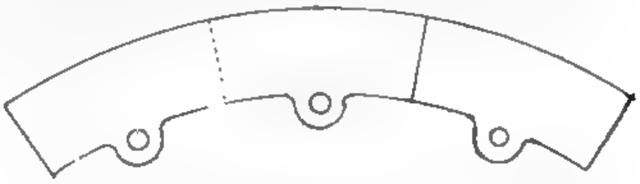


Fig. 16

in the section, the core has radial spaces at intervals for ventilation. In these spaces are also placed the gunmetal rings, on which are projections, forming the driving horns. The horns are not arranged in line as in the Crompton armature, but are placed at intervals so that the driving points are distributed about the conductors. The number is so fixed that the maximum pull on any horn is 60lb. The armature is wound on the zigzag principle introduced by Mr. Scott some years ago, and the bars are connected by the Kapp patent connector, Fig. 17. These are built up in the carriage, and then bolted as a whole on to the core, thus saving much time over any system in which the connectors have to be arranged *in situ*. Also, as the connectors run round concentric with and near the core, the internal parts are left open to the air, and a larger cooling surface is exposed.

Fig. 17.

Messrs. Laurence, Scott, and Co. show a well-made armature in the shiplighting plant they have lately added to their exhibit. The core is driven in the usual manner by a gunmetal spider, and is of the toothed type described above. They use deep grooves for the conductors, and claim a high efficiency. The armature is drum wound, and the Kapp connector is used. The ventilation inside the core is ample, and should ensure cool running. There is no doubt that with due care to the insulation of conductors when first embedded, it is impossible that any

strain due to the load should cause trouble. The weight efficiency of the dynamo will be seen in the next article.

The machines made by Messrs. Siemens Bros. and Co. have a good reputation for cool running, and the makers are naturally unwilling to publish full details of the construction. The general arrangement of the core is somewhat as follows, Fig. 18: The iron plates are keyed directly on to the shaft, and circular holes through them form the longitudinal ventilation spaces. At intervals there are radial gaps left, as explained in the machines described previously.

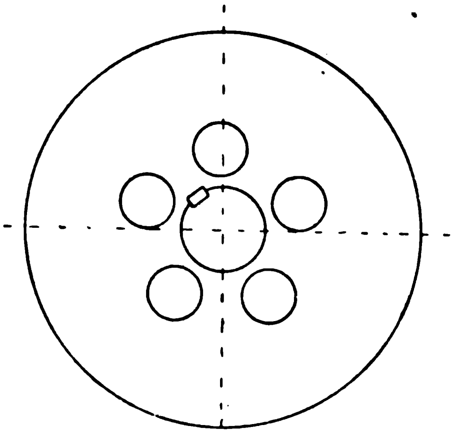


Fig. 18.

I also understand that the conductors are driven by means of pegs of metal or hard wood fixed into the core. The end connections used appear to be somewhat of the same kind as those used by Messrs. Crompton and Co. They take up all the space round the shaft, and must form a serious obstacle to the air entering the ventilating spaces. In the largest machine made by this firm the conductors are connected on their improved parallel system.

THE DISTRIBUTION OF ELECTRICITY FOR LIGHTING PURPOSES.*

BY J. BRENTNALL DUCKITT, GRADUATE.

Before drawing your attention to the various methods of distribution of electricity for lighting purposes, the writer thinks it will be well to say a few words with regard to the lamps used for electric lighting. These are of two kinds: arc and incandescent.

The arc lamp has been known in some form for upwards of 50 years, but it is only recently that it has been brought to anything like a state of perfection. Two forms are now used—namely, the single-regulating coil arc lamp, and the shunt-regulating coil arc lamp.

The single-regulating coil arc lamp is regulated by means of a thick wire coil or solenoid, through which the whole of the current passes. If the arc in the lamp becomes too long the solenoid, owing to the increased resistance, and consequent weakening of the current, will allow the carbon rod to drop, thus re-establishing the proper length of the arc. This type of lamp can only be used in parallel circuit; if it were put in series a constantly flickering light would ensue, as some lamp in the circuit would always be adjusting its arc and disturbing the others.

In the shunt-regulating arc lamp, the thick coil or solenoid is retained as before, but in connection with it is a fine wire coil arranged as a shunt to the arc; that is, when the current reaches the positive terminal of the lamp it has two paths open to it—one through the thick coil and the arc, and the other through the shunt coil direct back to the negative terminal of the lamp. If the arc becomes too long, the current through it would tend to weaken, on account of the increased resistance of the arc; but this would cause a stronger current to flow through the shunt coil, hence the current in the main wires is not weakened. If the arc becomes too short the resistance would be less, and the current through it would be stronger; this would cause a weaker current to flow through the shunt coil, so the current in the main wires is not strengthened. The shunt coil also controls the carbons as well as the thick wire coil, and by means of the two a practically constant burning lamp is obtained. In these lamps there are also placed automatic cut-outs, so that in case of the carbons burning out the circuit will remain open through the cut-out. Fig. 1 shows a Crompton arc lamp of this type.

Focussing arc lamps are those in which both carbons move towards the arc; they burn equally and keep the arc in one place. The new lamp of this type manufactured by Messrs. E. Scott, Mountain, and Co. was illustrated.

The distance between the carbons in an arc lamp, or, in other words, the length of the arc, does not vary much. In a 50-volt circuit and with a current of 15 amperes the distance is generally $\frac{3}{16}$ths of an inch. In a 40-volt circuit with 10 amperes $\frac{1}{8}$th of an inch is found best. These figures apply to powerful arc lamps like those used in street lighting, when worked in series. When worked in parallel they will require a higher voltage, say, 65 volts. The following table gives lighting power of arc lamps:

Nominal candle-power.	Current (amperes).	E.M.F. (volts).
1,000	5	65
2,000	10	65
3,000	15	65
4,000	20	65

The incandescent lamp is now so well known that it is hardly necessary to describe it. It may be regarded, however, as a short length of very fine graphite carbon, curved into a U-shape, and mounted in a pear-shaped glass bulb, from which all the air has been exhausted by means of a mercurial air-pump, so as to form a practically pure vacuum. The two ends of the filament are fixed to two pieces of platinum wire which are sealed in the glass. To make a perfectly conducting joint between the filament and the platinum, it is electrically coated with a layer of copper. The lamps need careful handling, as the filaments are very brittle and easily broken. If the glass be broken the lamp is totally destroyed.

The filament being carbon offers a high resistance to electricity, and if a current be forced through it work is done in overcoming this resistance; the work done takes the form of heat, the carbon becoming white hot, but being in a vacuum no chemical combustion takes place, and it is not destroyed. The higher this pressure or force the less the amount of current within a certain limit. The principal type of lamp used is 16 c.p., and the voltage generally 60 or 100.

The following table gives the E.M.F. and current of various lamps, and gives the limit over which incandescent lamps can be economically used:

Candle-power.		Volts.	Amperes.		Volts.	Amperes.
8	takes from	10	2·8	to	120	·3
16	,, ,,	15	3·7	,,	160	·4
25	,, ,,	40	2·2	,,	120	·7
50	,, ,,	50	3·5	,,	120	1·4
100	,, ,,	50	7·0	,,	120	2·9

High candle-power incandescent lamps, such as the Sunbeam lamp (shown) are now largely coming into use for the lighting of large rooms, halls, etc. These Sunbeam lamps are decidedly preferable to arc lamps, since they cast no objectionable shadows, give no hissing noise, and require no attention from their first instalment until they give way. They generally burn from 1,000 to 2,000 hours before their filaments break. They require a little more power to work than arc lamps. But taking everything into consideration, they are nearly as cheap as medium-sized arc lamps in a long run and far more satisfactory for large rooms, where perfect silence, freedom from blinking and shadows, as well as artistic appearance, are of importance. Arc lamps require daily attention, with the additional cost of fresh carbons, etc.

The various systems of distribution may be divided into two parts—first, the continuous-current method, and second, the high-tension alternating-current method. In all electric wiring there are two fundamental circuits—namely, series and parallel. The series system, Fig. 2, may be compared to the arrangement in an engine, where the same steam passes from one cylinder to another, giving up its energy

* Paper read before the Graduate Section of the N. E. C. Institution of Engineers and Shipbuilders.

in work, step by step, until it returns to the condenser. The boiler, feed-pump, and air-pump correspond to the dynamo, its negative terminal being the condenser, and its positive terminal being at the boiler stop-valve. Between these points the pressure is raised from a vacuum or negative pressure of, say, 12lb. per square inch, to a positive pressure of, say, 160lb., or 172lb. in all. In this case the steam passes through the cylinders in series, giving up its pressure on the way, the steam-pipes, ports, etc., corresponding to the conductors, the loss of energy in the conductors being reduced as much as possible, returning finally to the point of negative pressure at the air-pump suction.

The system of wiring on this principle is very good where there is a constant load at all points at which power is taken off. But suppose that the circuit of lamps be divided among six persons, and the fourth person only wanted to use one quarter the number of lights told off to him. By so doing he reduces the conditions of pressure in the other systems, because the pressure is proportional to the number of lamps, while the current remains constant, and this necessitates a reduction in the total difference of pressure at the origin and end of the system.

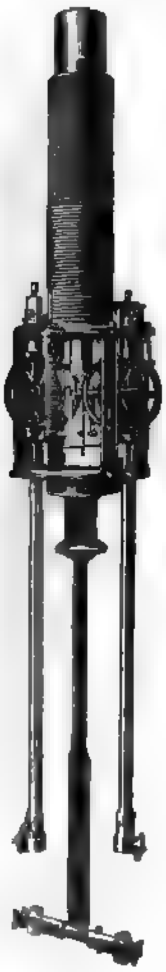


Fig. 1.

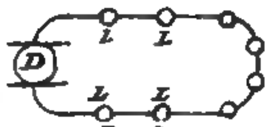


Fig. 2.

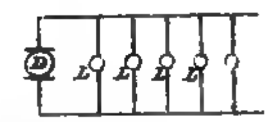


Fig. 3.

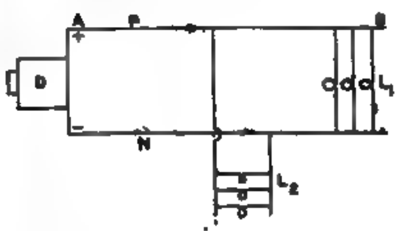


Fig. 4.

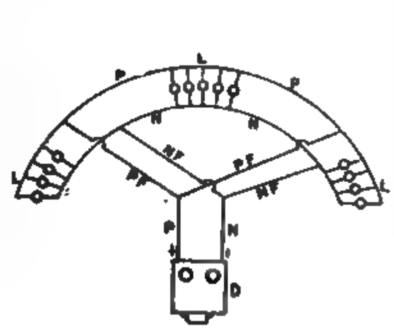


Fig. 5.

The Parallel System.—If a dynamo be turned round at a fixed rate it establishes a certain difference of pressure between the main wires, but no current flows until a lamp or lamps are connected across them. The current then flows through the lamp or lamps from the positive to the negative main. In this system the pressure remains constant, while the current is proportional to the number of lamps, so that if the number of lamps be increased the amount of current will have to be increased in proportion. In Fig. 3, let D represent the dynamo at the central station, L the lamps at the customers' houses, and P and N the two mains, in which the pressure must be kept constant everywhere on the circuit however many or few lamps are connected across it; the lamps being made all of the same resistance and size, will burn everywhere with the right intensity.

There is no difficulty in obtaining this even difference of pressure if the distance from the dynamo, D, to the lamps, L, is short, but if the distance is long there will be a great difference. The copper mains through which the current flows offer a certain resistance to its passage, and this, when very large currents are used, becomes a very important item. The energy thus expended by the current in forcing its way through the mains appears as heat, and if too great a current be forced through the mains they will become heated even to melting point: for this reason it is always necessary to proportion the mains to the current they will have to carry. Again, this generation of heat absorbs power, so care must be taken that a system of mains does not waste so much energy as to become uneconomical. From this will follow, firstly, that it will not do to go below a certain section of copper for a given current, or the heat of the conductor will be too much increased; and, secondly, that in attempting to send a current through too great a length of this conductor the loss of energy will be excessive. It may be here mentioned that the size of the conductor has nothing whatever to do with the pressure or E.M.F., but the amount of current alone. To get rid of these difficulties the conductor may be made very large, but this will also greatly increase the cost. For example: In Fig. 4 suppose the distance between A and B is one mile. An ordinary 16-c.p. incandescent lamp takes about two-thirds of an ampere of current at a pressure of 100 volts to incandesce it properly. Now suppose there are 1,500 lamps at L_1, all close together, they will therefore need 1,000 amperes of current at a pressure of 100 volts, and suppose that the mains are one square inch section, which is the usual size for 1,000 amperes. But 1,000 amperes through one mile of cable one square inch section would require about 100 volts to overcome the resistance alone, consequently the pressure at the dynamo would have to be increased to 200 volts, in order to get 100 volts at the lamps, L_1, and only half the energy generated at the dynamos would be utilised by the lamps, the other half going to overcome the resistance of the cable. Therefore the efficiency of the system would be reduced to 80 per cent., and the expense in copper would be enormous.

There are also other difficulties connected with this system; for instance, if there were only half the number of lights burning at L_1, then there would be only half the amount of current passing through the mains, and consequently half the resistance, thus making the voltage at B far too high. Another difficulty arises when a circuit of lamps is taken off at half the distance.

Now if there are only a few lamps burning at L_1 and L_2 the voltage will be about the same at each place, and the lamps will burn with nearly equal brightness. But suppose the full load was on the voltage at the dynamo would be 200, while at C it would be 150, and at B about 100 volts, this would directly destroy the 100-volt lamps at C, and the system would be perfectly impracticable. This, then, is the most troublesome fact which has to be dealt with in distributing current for incandescent lamps at low tension.

The first improvement on this system was the introduction of what are known as feeders—Fig. 5 is an example of this system. D is the dynamo, and from it run the usual mains, P and N, and the lamps are connected in parallel circuit, as at L L L. From the main conductor, P, there run other conductors, P F, which are the feeders, and join P in the outer circuit, while from N similar feeders, N F, run, joining N in the outer circuit. These feeders may be of any number, and their object is to keep the pressure constant all over the circuit. This certainly is a great improvement on the last system, but still the loss of energy per unit length of conductor remains about the same as before, and still binds down the area over which current can be distributed in this manner within very narrow limits.

The next great improvement was the three-wire system. This system is shown in Fig. 6. D and D are the two dynamos, each rotating in the same direction and sending equal current and pressure into the mains P, N, and O. If O is separated into two mains, one from each machine, there would be two equal currents flowing in opposite directions, but by joining them across the terminals of the dynamo they just neutralise each other, and the single main, O, is joined [illegible]

O may be only of very small strand in comparison with the former mains, as it will only serve to carry current in the case of a lamp breaking or being otherwise put out. By doing this other advantages are also obtained, because the difference between P and O is 100 volts, and between O and N is likewise 100 volts, therefore the difference between P and N is 200 volts, and from this it will be seen that to send double the amount of energy along the mains P and N only the same amount of current is needed, so that the loss remains the same as formerly, but this loss is spread over two lamps instead of one, thus reducing it to half. By this system only one-third the weight of copper is used as compared with the others, or with the same weight of copper the current can be carried three times the distance with the same loss. It will be seen that this system is simply a device for burning two lamps in series, so that if one lamp goes out its complementary lamp will not go out, but will form in circuit with the main O. This system is also often adopted for high-tension circuits or circuits of high E.M.F.

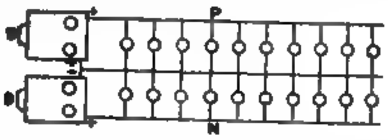


FIG. 6.

Another system that may be mentioned is the system of accumulators, in which accumulators are placed in the circuit and charged through the day. These cells are fitted with a very ingenious arrangement which is intended to control them completely, so that, when the cells are fully charged they will break the connection with the dynamo, and throw themselves in circuit with the lamps, and will likewise re-establish connection with the dynamo when they have run down to the point at which it is desirable they should be recharged.

It is obvious from these facts that the low-tension continuous-current system can only be economically applied where the installation is close to the dynamo, and consequently in the immediate neighbourhood of the station.

High-tension continuous currents are very seldom used for incandescent lighting, but chiefly for arc lamps in series, as has already been stated in referring to the series system.

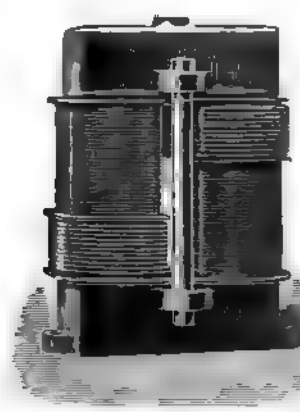


FIG. 7.

In 1882 Edison patented a rotating transformer, which was simply a dynamo and motor combined. The idea was to generate a high-tension current at the central station, and transmit this through small conductors to the distributing stations, where the current worked a motor which had in connection with it a dynamo, which produced the low-tension current to drive the lamps. The arrangement, however, is costly, as these transformers being machines in motion need constant attention.

Having now mentioned the principal methods of low-tension continuous-current distribution, a few words may be said on the alternating-transformer system.

The induction coil, which was invented by Ruhmkorff, and which is probably known to all in the modified form of the medical coil, consists of a central core, which is simply a bundle of soft iron wire. On this is wound what is known as the primary coil, which consists of a thick coil of insulated copper wire. Over this is wound a great many layers of very fine well-insulated copper wire, which form what is known as the secondary coil.

On a current of large quantity but low E.M.F. being sent through the primary coil, a very high E.M.F. but a small current is induced in the secondary coil, but this induced current is only instantaneous, and the instant the current in the primary ceases or is cut off, an equal and opposite high-tension current is induced in the secondary. In order, therefore, to keep up this high-tension current it is necessary to have the induction coil fitted with a contact breaker in the primary circuit to quickly make and break the flow of current, or a commutator to produce rapid

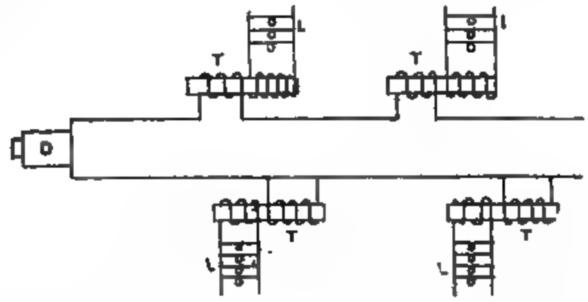


FIG. 8.

alternations, thus producing high-tension alternating currents in the secondary coil, which are similar, though of greater pressure or E.M.F., to the current produced by the alternating-current dynamo.

If the process is now reversed, and an alternating current of high tension is sent through the secondary, it will produce an alternating current of low tension in the primary, but of far greater quantity or number of amperes. Hence, if a high-tension alternating-current is produced in a dynamo, it can be transmitted to a distance and there converted into a low-tension current to be utilised for lighting purposes. These converters are what are called transformers, Fig. 7.

By transmitting in this manner it would require a much smaller conductor than in the case of low-tension currents, thus reducing the cost very considerably. For example, it would require a cable consisting of seven strands of wire, No. 20 gauge, to carry 10 amperes at 100 volts low-tension continuous current, but the same cable would carry 10 amperes at 1,000 volts high-tension alternating current, in one case carrying

$$10 \times 100 = 1{,}000 \text{ watts, and in the other}$$
$$10 = 1{,}000 \times 10{,}000 \text{ watts.}$$

That is, 10 times the amount of energy in the case of the

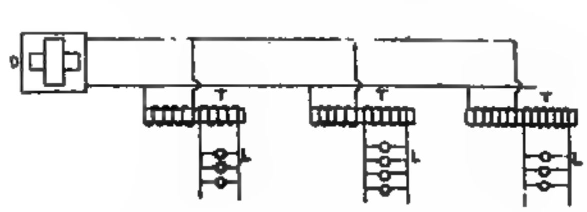


FIG. 9.

high-tension alternating current at the same cost for conductors or mains, and at the same time to a far greater distance.

Transformers may be made to work either in series or in parallel. In Fig. 8 (the ends of the mains should be connected) they are arranged in series.

This system is successful for the transmitting of energy for electric motors, etc., but it is of no use in distributing for lighting purposes, as the current being constant and the E.M.F. varying, the lamps would not be independent of one another.

In 1885 transformers were first arranged in parallel, Fig. 9, the primary coil of each transformer being connected across the two mains in exactly the same manner in which incandescent lamps are in the case of low-tension currents. This system is a great improvement on the

series system, as the current varies and the E.M.F. is always constant.

There are at present several different forms of transformers in use. Some makers prefer a straight iron core, and have the primary and secondary coils wound upon it side by side, but well insulated from one another. In Hopkinson's transformer, the core consists of iron wire wound in the shape of a ring, and the coils are wound on this. The transformer made by Messrs. Scott, Mountain, and Co., and which has already been brought before the institution in Mr. Mountain's paper, consists of a square magnetic circuit, upon which two pairs of primary and secondary coils are wound, Fig. 7.

The primary coil in a transformer consists of a long thin wire, and the secondary a short thick wire. The length of the wire in these two coils is determined by the difference of voltage required. For instance: Suppose the potential difference in the mains is 1,000 volts, and the lamps in the secondary circuit are 100 volts, then the ratio of the two voltages is 10 . 1; therefore the primary must have 10 times the length of wire there is in the secondary. But the secondary will have almost 10 times the amount of current induced in it; it must therefore have 10 times the area of section. This decides the relative lengths only. There is a certain amount of loss due to the magnetising of the iron core.

From this it will be seen that by using a high-tension alternating current electricity can be spread over a much larger area, using much smaller conductors, and reducing it by means of transformers to low tension and consequently to the lamps. But there is also the extra cost of the transformers, and the loss due to magnetising the cores, etc., in them.

It may be here mentioned that transformers under 2 e.h.p. do not work economically, so in lighting shops or houses, where only a few lights are required, it is advisable to make one transformer supply two or three customers situated close together, each having an independent meter.

With regard to the lamps, incandescent lamps work just as well with alternating as with continuous current. Arc lamps which are to work in alternating-current circuits are similar to ordinary continuous-current arc lamps, only the iron core which works in the solenoid or coil should consist of a bundle of very soft fine iron wire instead of one solid bar. This is to help the rapid changes of polarity due to the alternating current, and also to prevent eddy currents and heating. The carbons which are used in these lamps are both the same length, as both burn at equal rate, while with the continuous current the positive carbon burns away twice as fast as the negative, and has therefore to be twice as long.

TESTING FEES AT BIRMINGHAM.

The Corporation of Birmingham give public notice that the following scale of fees will be adopted to be taken by the electric inspector appointed by them under the said orders—namely:

Mark.	MAINS, SERVICE LINES, ETC. Tests to be taken.	Fees. s.	d.
1.	Insulation of main, each test	5	0
2.	Conductivity of main	7	0
3.	Insulation of service lines	2	6
4.	Conductivity of service lines	4	0
5.	Efficiency of joints	3	6
6.	Supply of energy at testing stations, per station, per diem	2	0
7.	Tests of instruments of undertakers, per instrument	1	0
8.	Tests of electric lines of undertakers, other than mains and service lines, each test	2	6

Mark.	METERS Nature of work done.	Fee. s.	d.
A.	Testing and examining a meter, and issuing a provisional certificate	7	6
B.	Visiting a consumer's premises on written requisition, and examining or reading a meter, or inspecting the fixing or unfixing thereof, for each visit	3	6
C.	For each additional meter upon the same premises, and at the same visit	1	6
D.	Testing and examining a doubtful meter	12	0

WORCESTER.

A report has been submitted to the Electric Lighting Committee of the Worcester Town Council by Mr. W. H. Preece, who was called in to adjudicate upon the various schemes sent in response to advertisement. The occasion is an interesting one, as it is the first which has adopted on any large scale the asking for the submission of projects as contrasted with the invitation of tenders to definite specification. The actual report is not yet made public, but it is understood that the committee are in favour of the lowest tender—that of the Brush Electrical Engineering Company for £21,005. We are able, however, to give the general outlines.

The report states that all the principal firms have tendered. There are 14 distinct systems, 10 being high tension and four low tension. Of the 10 high-tension schemes, seven are for alternating-current and three for continuous current distribution, but it is interesting to note that the high-tension continuous systems are quoted by far the highest of all tenders. Every scheme proposes to use the three-wire system. The low-tension advocates claim the advantages of economy in first cost and working (not supported by figures), the use of motors, storage of energy, extra safety, and greater efficiency. The advocates of alternating systems claim economy in prime cost, especially in mains (supported by figures), adaptability for pioneer work, great elasticity, simplicity in working, power to place the central station where coal and site are cheapest.

The question, the report states, is not danger, but efficiency and cheapness, as alternating current is now made as safe as direct current. There is no reason not to accept the lowest tender. The great objection to open tenders of the kind asked is that those tendering have a tendency to cut things too fine, and leave out essentials, trusting to being able to obtain extras. Several tenderers leave out essentials, such as water connections and condensing pumps, opening and closing trenches, supply of meters, spare parts, provision for expansion.

Amongst the other really necessary parts of an efficient installation which are omitted in the competitive projects are those which provide for economical working, such as heat economisers, mechanical stokers, feed-water heaters, lagging to steam pipes and boilers. The report states that there would be great loss of energy in the mains on present projects. There is an absence of testing appliances, and a general curtailment of the secondary distributing system. The Brush Company are among the least offenders in this respect. There will not be many extras on their tender. Those that are not specified are railings to machinery, chequered floor plates, and travelling cranes. The next lowest tender omits opening and closing trenches—a most important item.

The report recommends the introduction of arc lamps (50) in the streets, as likely to create public feeling in favour of the electric light. Those towns which have introduced arc lamps have had success, while those, like Leamington, which have introduced incandescent lamps for public lighting have made a failure. The income from the installation (which is for 12,000 8-c.p. lamps) is estimated at £10,800, at 6d. per unit; the working cost at £5,400. The average revenue per 8-c.p. lamp will be 9s. per annum, comparable to 5ft. gas at 3s. per 1,000. The preferable site is at Diglis Lock, using water power. The cost of building is estimated at £6,700; a station in town would be £5,000, so that this is only £1,700 extra. The report estimates total cost as follows:

Contract	£21,005
Extras	1,000
Street lighting	5,000
Building	6,700
Working capital and for extensions	6,295
Total	£40,000

The consent of the Local Government Board must be obtained for this amount.

The report is to be submitted for confirmation to the Town Council.

THE

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TELEPHONY AND THE POST OFFICE.

On Tuesday another discussion arose in the House of Commons based upon Dr. Cameron's motion:

"That the Post Office system of granting licenses to private telephone companies having resulted in the restriction of telephonic communication in this country, and a costly and inefficient service, this House is of opinion that, alike in the interest of the postal telegraph and the telephone service, the telephonic monopoly possessed by the Post Office should be worked directly and in connection with the Postal Telegraph Department."

This motion, after along discussion, was rejected by a majority of fifty-eight. We considered this question in our issue of March 4th, since when there have been various public utterances on the subject, which continue to make the matter prominent. The latest policy of the Government is to obtain the trunk lines and allow private companies to do the rest. As we said before, "that plan may be workable—we doubt it." So far as outsiders can see, the Government policy has, during the past decade, been that of Micawber—always waiting to see what would turn up. Of all the proposed solutions to the problem there is but one looming out more and more distinctly as time moves on—the nation will have to undertake the work. There is no help for it, and all the fallacies put forth as arguments point to this one result in the end. Successive Postmasters-General may temporise, successive Chancellors of the Exchequer may vacillate, but the inevitable must come, and the sooner that fact is faced the better for all concerned. It is admitted that the Government has a monopoly of the telegraphs; it is admitted that the nation paid heavily for that monopoly. The balance-sheets issued year by year, however, show that the country has never received even a moderate return for its capital. And whatever be said to the contrary, we contend the nation has a right to expect, not only that the expenses be paid, but that the interest it pays upon the capital be also earned. Till that point is reached the investment as a business transaction is a failure. The Government receives 10 per cent. from the telephone companies upon their receipts. Does that amount, be it £46,000, the sum mentioned as paid by the National Company, or twice £46,000, recoup the Government for its loss on its other telegraphic business? If it does, there is no more to be said—the country is no loser; but, on the other hand, if the amount received is less than that lost, the country is by so much a loser. There is no difficulty in proving the latter to be the case. Our argument is that the loss is the difference between the 2¾ per cent. paid by the Government on the requisite capital, and the 4½ to 6 per cent. paid by the National, not only upon its required capital, but upon its watered capital. When 4½ per cent. is paid upon capital, say, doubled by watering, it means 9 per cent. upon requisite capital. The loss to the Telegraph Department as telephonic competition becomes keener will be a gradually increasing one. Telephony now absorbs a large part of the local traffic, and with well-

managed trunk lines, in addition to the local lines, will absorb the interurban traffic. Neither the supporters of Dr. Cameron's motion nor those opposing it put these facts clearly. They relied upon a desultory discussion about consolidation of companies, inefficiency of the great London company, watering of stock, and procrastination of official decision to waste an evening. Mr. Quilter took part in the discussion on behalf of the telephone company, and candidly admitted the badness of the London service; but, says he, in effect, see, if we can't give a good service in London, we or someone else can elsewhere. Between Manchester and Liverpool in one day 42,000 messages pass—that is, a message every two seconds during twenty-four hours, or every second during twelve hours. Over a trunk line, too. Good business; but is it quite accurate? We quite agree that the Government cannot continue a competitive service in towns where they also grant licenses. The exception to the rule that the Government service is least patronised is hard to find. At Leicester, Mr. Quilter said the Government had in 1890 subscribers to the number of 130; now they have 100, while the company in eighteen months put on 275. We might add other examples to that of Leicester. Thus, the Post Office has exchanges at Cardiff, Newport, Barry, Pontypool, Talywain, Aberdare, Merthyr, Ebbw Vale, Briton Ferry, and Swansea in the South Wales district, with subscribers in December, 1890, numbering 122. The licensees have exchanges in these places except Talywain, and in one or two other small towns with 638 subscribers. In 1891 the competitors were on their mettle. The Post Office added 73 subscribers against the licensees' 140, the respective totals being 195 and 778. The Post Office reduced their rates from £21. 10s. for the mile radius, £16. 5s. half-mile, and £14. 10s. for the quarter-mile, to £14 for the mile, £12 for three-quarter mile, £10 for half-mile, and £8 for quarter-mile. The Western Counties rates were £12, £11, and £10 for the mile, according to period; they had no half-mile rate prior to the reduction of rates by the Post Office.

The multiplication of small exchanges in a town or district belonging to competing interests is not conducive to supply the wants of subscribers, and unless the policy of the Post Office is to be to instal their own exchanges everywhere, the system should be avoided. This policy is a mere tinkering with the nation's money, and has little in common with true business principles.

THE LANE FOX v. KENSINGTON JUDGMENT.

In our last issue we discussed this case from a point of view which applies to all similar cases, with the specific object of combating ideas freely expressed as to the necessity of technical judges. Our opinions were adverse to such a system. The judgment upon the case having been reserved, and not then delivered, we were unable to comment upon the proceedings. Now, however, reserve is no longer necessary, and freedom of comment is permitted. Mr. Justice Smith has given his verdict upon the lines expected. According to the evidence, he could not do otherwise than say the patent was infringed—if he held the patent to be valid. The patent has been held to be invalid, hence Lane Fox loses his case. The evidence given in this case will long continue to be a monument of absurdities. Hardly a witness attempted to confine himself to the knowledge of 1878, and the whole case may be reckoned as a flagrant attempt to interpret disconnected sentences strung together in 1878 by the increased knowledge of to-day. It was left to the Judge himself to find items among the mass of evidence which should enlighten him as to what was really known in 1878. The Kensington case was lost as to infringement by the evidence of their own witnesses, and by evidence that was due to utter ignorance of really what was known in 1878. The point which had an enormous influence upon the success or non-success of Lane Fox was that the final of his patent contained matter taken verbatim from the provisional of another patent, and was not an extension or development of its own provisional. To the unbiassed mind this was proof positive that when the second provisional was taken out Lane Fox himself regarded the matter as subject for a new patent, and not as a discovery or invention existing within the words of the original patent. In other words he, in 1878, showed his hand and destroyed the edifice he would in 1892 have us believe he was about to construct. Mr. Justice Smith found the patent was unworkable, but Lane Fox showed he thought so too in 1878, though his contention in 1892 was to the contrary effect. Another point which undoubtedly had great influence upon the judgment was that for several years after 1878 Lane Fox was in a position to test his invention, and to use his invention to the utmost, but his evidence pointed to the fact that so little was he then enamoured of his production that he practically did not trouble about it, but concentrated his whole endeavours in another direction. After modifications were introduced, after successive disclaimers in the hope that something out of the original might be left upon which to found a claim, after research, improvement, and development by others, he comes forward in an attempt to rule the roost—an attempt which has but narrowly escaped being successful. We never saw a better fight. His counsel omitted no effort to win; it is not their fault, nor the fault of his witnesses—they were all indefatigable: the inherent weakness of the case was the result of its failure. There are some portions of the evidence upon which we intend to comment in another manner. Just now it is the result, not the evidence, we are passing under review. Still, a word may be said about the sins of omission. Much was made of Planté's book, little of Planté's work. There were men in court who had seen Planté's experiments—there were dozens, scores, or hundreds who saw the Paris Exhibition experiments of 1878. If we mistake not, there were many times during that exhibition that Planté had his connections exactly as Lane Fox says he meant his to be—that is, the source, the secondary battery, and the incandescent wire were all in parallel. We are speaking from memory, but that is the best of our recollection, having seen the experiments again and again performed by Planté we-

the wing of the late Count du Moncel. Besides these points, the counsel for the defence laid stress upon the lack of originality in the combination, though the evidence upon the point was particularly weak, while it might have been considerably strengthened. In 1878, everything Lane Fox claims was well known. Parallel incandescent lighting was well known, and its possibilities known. What was wanted was the lamp. The supply of current by parallel wires was well known, therefore there was no invention in the parallel supply. The invention, if any, would have consisted in putting a secondary battery parallel with the source and lamps. Such batteries had then been used for incandescing parallel strips of metal—not, perhaps, directly for lighting purposes, but to show the different incandescence to which the same lengths and sections of metals would rise when put between the same mains. We must congratulate the industry in having overturned the pretensions of those who have tried to claim a position to which they had no right. In the whole history of patents we fancy this is the first example of one being killed upon its death-bed. Fourteen years ago the patent was taken out. The life of a patent is for fourteen years—hence, in the natural order of things, this patent would have lapsed a little later in the year, but it has been summarily dismissed a little before its time.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

CRYSTAL PALACE EXHIBITION.

SIR,—I fear the Electrical Exhibition at the Crystal Palace has not many attractions for ladies, judging from the effect it had on my wife, who, hearing me say so much in praise of it, started off by herself yesterday afternoon to see it, after getting instructions from me where to go and what to look for. In the train she was interested in some small boys also going there, one of them asking if amperes were good to eat, and another hoping to buy a volt for a halfpenny and take it home to play with. On arriving she hunted for the Brush exhibit, and at last found it in a glass case in one of the aisles; she thought some of the brooms were nicely made. She could not find the crane, and the only bird she saw was an owl with four eyes all round it, also a stand of things like pickle-jars and chimney-cleaners. Being very domesticated, she went to see the cookery. There were several things going round, and plenty of electricity about that smelt like burned fat—perhaps they were frying amperes; then the lecturer, who spoke very nicely, asked for a hat and a pancake was handed round. She thinks the pancake was cooked in the hat, as she had seen that done elsewhere. After wandering among a lot of glass jars full of electricity that smelt very nasty, she went up in a nice lift (she is rather stout) to the galleries, saw all the pictures and the furniture stalls, and in them at last she found the crane, also the screen that she had looked for in vain downstairs. But there was no electricity about them that she could see or smell, so after seeing all the lamp stores and avoiding the noisy machinery, she came home rather out of temper, so you may guess I spent a pleasant evening.—Yours, etc., X.

CONDUITS.

SIR,—The note in your issue for to-day with reference to the electric lighting of Buchanan Castle, conveys the impression that the electrical conduits that have been successfully employed at Cragside, Lord Armstrong's place in Northumberland, for some years past were designed, or at all events introduced, by Messrs. Drake and Gorham.

I am sure that this firm would not desire to convey so erroneous an impression, but I may mention that, as a matter of fact, the conduits in question were designed entirely by Lord Armstrong and myself some considerable time before the coming into existence of the firm of Drake and Gorham, and were erected by Lord Armstrong's own estate workmen.

It is probable that these conduits were the first practical example of bare conductors laid on insulators in troughs, a method since largely adopted; but the arrangement was never patented, so it is open to anyone to copy it.—Yours, etc. A. A. C. SWINTON.

March 25, 1892.

AN INTRODUCTION TO QUALITATIVE CHEMICAL ANALYSIS.

BY BARKER NORTH, ASSOC.R.C.SC. (LOND.),

Joint Author of "Introductory Lessons" and "Hand-book of Quantitative Analysis."

(Continued from page 256.)

Evaporation.

This process may occasionally have to be resorted to after solution, and will always have to be performed in testing for the metals sodium and potassium in the wet way in presence of other substances.

It is generally performed by heating the solution in an evaporating-basin, by means of a Bunsen burner, till the liquid is reduced to a convenient bulk for analysis (Fig. 7). If the

FIG. 7.

liquid has to be evaporated to dryness, the heating is carried on in the same way till the substance is obtained in the dry state, and in the presence of ammonium salts, which it is necessary to get rid of, the heating is continued till the substance ceases to give off fumes of ammonia. This may be attained much more quickly by transferring the dry substance to a piece of platinum foil and holding this with a pair of crucible tongs in the Bunsen flame.

Experiment 22.—Evaporate a solution of ammonium chloride to dryness. Observe that the substance entirely disappears in white fumes on heating (see Fig. 7).

PRECIPITATION.

After obtaining the substance in solution, the next process is to precipitate the metal or metals in an insoluble state, and this is accomplished by gently pouring a solution of the reagent into the liquid, hot or cold as the case may be, and afterwards warming if necessary. When the reagent to be employed is a gas, it is bubbled through the solution till the whole of the substance is precipitated. Care should be taken never to add a large excess of the reagent, except when otherwise stated.

Experiment 23.—Make a solution of lead nitrate in water or use the solution made in Experiment 19, and add dilute hydrochloric acid drop by drop to the *cold* liquid till no more precipitate seems to form. The white insoluble residue thus formed is due to the reaction taking place between the hydrochloric acid and the lead nitrate in accordance with the following equation:

$$Pb(NO_3)_2 + 2HCl = PbCl_2 + 2HNO_3.$$

The precipitate on boiling will disappear, as it is soluble in hot water, but on cooling will reappear in the form of long, white, acicular crystals. Keep for future use.

Experiment 24.—Make a dilute solution of cadmium sulphate ($CdSO_4$) and pass sulphuretted hydrogen gas through the *cold* liquid (Fig. 5); a fine yellow precipitate of cadmium sulphide will be formed, as shown in the following equation :

$$CdSO_4 + SH_2 = CdS + H_2SO_4.$$

The sulphuretted hydrogen may be prepared (as shown in Fig. 8) by pouring dilute sulphuric acid down the thistle funnel on to ferrous sulphide contained in the Woulff's bottle, A, and, after washing by passing through water in

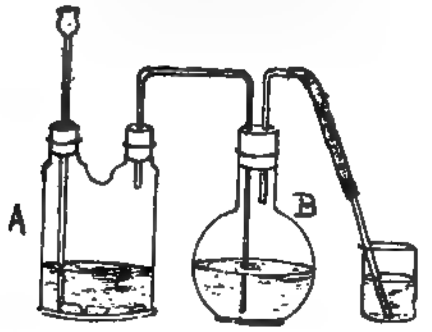


FIG. 8.

the flask, B, it is bubbled through the solution containing the cadmium ($FeS + H_2SO_4 = FeSO_4 + SH_2$).

FILTRATION AND WASHING.

The next process, after the metal or metals have been precipitated in the insoluble state, is to filter off the precipitate from the liquid, the latter being now called the filtrate. In order to do this, a filter paper about 4in. in diameter is folded in half, refolded into a quarter of its original size, and then opened out in the form of a cone, with three layers of paper on one side and one on the other This is fitted into a glass funnel, *a* (Fig. 9), supported on a wooden filtering stand, the paper being fixed in position by wetting with a little water, and the precipitate and liquid are then poured in, the filtrate being caught in a small beaker placed underneath.

When the liquid has all drained away, it will be necessary to wash the precipitate three or four times with hot or cold water in order to remove the last traces of the filtrate from the precipitate. If the washing is not carried out

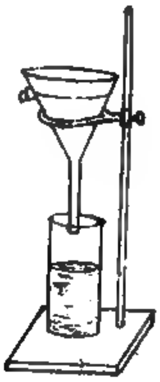


FIG. 9

conscientiously, the student will have some of the solution belonging to the filtrate interfering with the reactions given by the precipitate, in which case the best way is to throw the whole thing down the sink and commence again. The washings may in any case be discarded, as they contain very little substance, and in qualitative analysis we can afford to neglect this, as it only serves to inconveniently accumulate the filtrate. Before the student, however, can begin washing it will be necessary to furnish himself with a wash-bottle.

(To be continued.)

SOME ELECTRICAL INSTRUMENTS.*

BY ROBERT W. PAUL

The increasing number of cases in which accurate electrical measurements have to be made renders it more than ever necessary to devote attention to the design of instruments, with the object of making their use more convenient and expeditious, as well as accurate. Consider, for example, the form in which the standard ohm is usually constructed, the coil having two or more layers of

FIG. 1.

many turns each; in using such a coil for accurate measurement there is considerable delay in waiting for the temperature of the coil and water-bath to become uniform and equal, and even then an uncertainty remains as to whether the turns near the top of the coil are at the same temperature as those at the bottom. After heating the bath, even with stirring, the water at the top may be at a higher temperature than that at the bottom. The surface, too, from which heat generated in the coil may be got rid of by conduction and convection is comparatively small. Prof. Fleming, in a paper read before this society in November, 1888, pointed out these disadvantages, and described a coil in the form of a ring of square section, which to a great extent obviates them; but even this coil has some length, and it has seemed possible to go still further in this direction, and at the same time to simplify the construction.

In the ohm coil shown in Fig. 1 the wire is wound in a flat spiral, being first doubled on itself in the usual way to avoid self-induction. The spiral is enclosed between two thin brass plates, forming part of a very thin, flat, water-tight box, and the electrodes pass up a central tube. The wire is thus at one level in the liquid, and has, therefore, a better opportunity of acquiring a uniform temperature, which may be accurately ascertained by a delicate thermometer passing down the centre, with the bulb at the level of the spiral. A second thermometer in the water at the same level serves to check the uniformity of temperature. In order

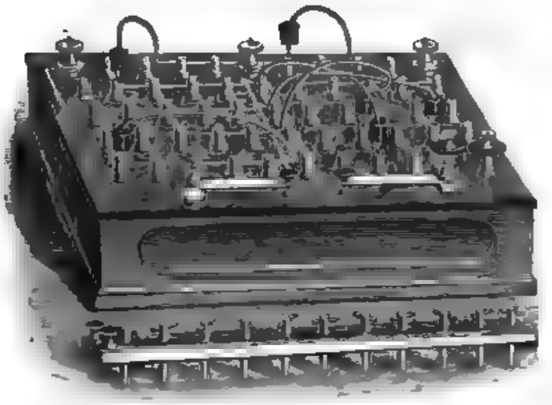


FIG. 2.

that the width of the coil may not prevent any slight convection currents from having free play, the screws which hold the plates together have large holes through them. Following Prof. Fleming's suggestion, the upper ebonite insulator is formed into a cup to contain paraffin oil to prevent surface leakage through condensed moisture.

The resistance-box shown in Fig. 2 is the outcome of some attempts to improve the ordinary form. The coils are arranged in sets of 10 each, and their ends are connected to sockets fixed in rows on an ebonite board. Successive coils are put in circuit by placing a plug, attached to a flexible cord, in the required socket; thus the resistance may be increased from 1 to 11,110 ohms by

* Paper read before the Physical Society, March 25, 1892.

steps of one ohm if necessary. The advantages which accrue from this arrangement are found to be as follows. The danger of surface leakage across the ebonite from block to block in the ordinary form, where the narrow gap between them is not easily kept clean, is obviated by the large open space between the sockets. The contact resistance in circuit is constant, and easily measured; it is reduced to a minimum by each plug fitting solidly the contact over the whole of its circumference, instead of on about one-third of it, as in the ordinary form. The hole between the blocks of an ordinary resistance-box alters its form with temperature, or any warping of the ebonite board, but the contact resistance at these sockets is not affected thereby. A rise in temperature of 20deg. C. will make the longer diameter of an ordinary resistance-box plug-hole ½ per cent. greater than the shorter, owing to the difference between the coefficients of expansion of ebonite* and of brass. The flexible cords each consist of between 200 and 300 strands of fine copper wire, and are not found to be affected by use. In using the set of coils as a Wheatstone bridge, or as an ordinary resistance-box, the rapidity and ease of adjustment of the well-known "dial" form are preserved, while the instrument is more compact and portable; the plugs being attached to the instrument are not liable to be mislaid.

But the arrangement of the instrument renders it available for several other uses. By means of the special contact bar, shown in the illustration, from two to ten coils in each row may be placed in parallel, thus making the instrumentavailable as a conductivity box of large range, for measuring low resistances. For the measurement of currents by the voltmeter method, 10 one-ohm, or 10 one-tenth ohm coils may be placed in parallel to give accurate resistances of ·1 or ·01 ohm of good carrying capacity. Several derived circuits may be made in the one resistance-box. By means

Fig. 3.

of the contact bar large ratios between two resistances, of great importance in the construction of high resistances, may be accurately obtained. To do this, the method described by F. Kohlrausch† is employed; for example, one set of 10 coils being put in parallel so as nearly to equal the other set of 10 coils in series, the small difference (error) between the two is ascertained by Foster's method; then each of nine of the higher resistances being checked against the first of its series, all the data for finding the exact proportion between the first coil of the one set and the other set of 10 in parallel are ascertained. The set of coils may be used as a potentiometer by connecting the battery to its terminals and using a pair of travelling plugs, between which any resistance from one to 10,000 ohms may be included.

The reflecting galvanometer illustrated in Fig. 3 has coils enclosed in ebonite boxes turned out to fit them. They are wound in accordance with Sir W. Thomson's law for the greatest magnetic effect at the centre, each being provided with its own terminals. They can be joined up as desired, and a pair of high or of low resistance coils may be used on the same instrument. When used as an astatic galvanometer, one of the needles is placed at the back of the mirror in the thick metal box below the coils, and the plug which carries the window in front may then be pushed in to aid in damping the vibrations of the needle by air friction. The needle may be easily removed, the suspending fibre passing through a slot in the case. It can be replaced by a ballistic needle, in which case the mirror carries no magnets, and the air damping can be minimised by sliding out the plug. This part of the instrument is mounted on an ebonite pillar so as to give good earth-insulation, and the directing magnets are placed at the bottom, so that they may be adjusted without setting the instrument in vibration.

* As given by Mayer, *American Journal of Science*, xli., p. 56, 1891.

† *Annalen der Physik und Chemie*, xxvi., 1887.

INSTITUTION OF ELECTRICAL ENGINEERS.

At the meeting of the Institution on March 24, the following discussion took place on Mr. Reckenzaun's paper on "Load Diagrams of Electric Tramways, and the Cost of Electric Traction":

Mr. Macmahon said he had not found such large variations of the volts as Mr. Reckenzaun mentioned. In his own practice he had occasionally found as much as 130 volts variation when running his dynamo simple shunt, or when the belt slipped; but when running compound, the maximum range was from 420 to 500. Mr. Reckenzaun's curves were obtained from readings taken every five seconds; if they had been taken by a recording instrument they would, he thought, have been found very much more rounded, the tops of the peaks being often quite flat for two seconds together. The current curve of a line when eight cars are on at once, he had found to show comparatively moderate variations, say, from 100 to 300 amperes, and never dropping below 80. When the number was reduced to five cars, the current was very irregular, and frequently dropped to zero. With 10 or more cars, and volts varying proportionately to what they now do for five cars, he thought the average variation would not exceed 10 per cent. He did not believe in the use of accumulators as steadiers, and considered them as rather a nuisance.

Mr. Volk said it was desirable to equalise the load on the engine as far as possible, as it was very uneconomical to have the latter several times more powerful than was required for the average load. He said that at Brighton he had a one-ton flywheel running at 160 revolutions on a 12-h.p. engine, and was able to start two cars at once, whereas with a light flywheel the attempt would have pulled the engine up. The cost at Brighton was about 4d. per car mile, running 23,000 car miles per annum. It was an edge rail track, which made the power required considerably less that on a street line with grooved rails.

Mr. Baker, of the Thomson-Houston Company, said that the German figures in the paper were new to him. Mr. Reckenzaun had referred to the low cost of labour there as compared to America. How did the cost of labour and fuel in Germany compare with that in England? In putting down a plant in England, the data obtained from American experience had to be much modified. He had obtained from America a motor which had given very good results there, and had found that it was not nearly so satisfactory in Leeds, where he used it in November on different rails and muddy streets. He employed a large staff to investigate the results, and ascertain the differences of the conditions compared with American practice. His expenses were therefore much greater than those of a purely commercial line. On this account he hesitated to give the figures that Mr. Reckenzaun had asked for without prefacing them with the explanation of how it was that they were so much in excess of the American ones, where everything was cut and dried. The following costs per car mile were obtained from an average fortnight's run. General expenses (salaries, office expenses, etc.) 1 13d.; transport expenses (including drivers, conductors, and inspectors), 5·17d.; maintenance of equipment, ·33d. He had some difficulty in getting a competent staff accustomed to motors, and had been obliged to get two men at high wages from America to instruct them; his head engine driver alone got £3 10s. per week. Their engine, too, was running much under its full load (a 200-h.p. engine running at 75 h.p.) Five cars were plenty to do the work all the week, but on Saturday and Sunday 50 or 60 would not be too many. He sometimes had 116 people on a 60ft. car. There was therefore plenty of reason for the transport expenses being so heavy. The maintenance of equipment was principally for new wheels, the original ones not being suitable to the rails used at Leeds.

Mr. Russell showed a diagram of current on the Hague-Schevening line; outside the town, running at about 14 miles per hour on T-headed rails the tractive force on a straight level was about 20lb. per ton. In town the speed was seven miles per hour. The cars weighed 17 tons (including batteries and passengers). 200 cells were used, two in parallel in town and all in series outside. Each run (about 30 minutes) required about 20 ampere-hours, of which nine ampere-hours were expended in starting from rest and getting up to normal speed. The start averaged five or six per mile. The average horse-power over the run out and back was about 13. In reply to a remark from Mr. Kapp that 17 tons per car was exceptionally heavy, Mr. Russell pointed out that this included 200 cells and 60 passengers.

Mr. Dolby thought that a great deal of power was lost in starting from rest with a rigidly-geared motor, and thought it would effect a great saving if the motor were allowed to attain its normal speed and were then put on by friction gear with considerable slip at first.

Mr. Manville thought that the engine might be spared a good deal of strain by the use of a set of accumulators—not the ordinary expensive type, but plain lead plates; these would charge when the load suddenly dropped, and would help the engine for a short time when a number of cars were started at once. Electric trams would, he said, never be really successful as long as a clause for the protection of the telephone companies prevented the use of earth return. It was practically impossible to run a two-wire overhead line. A Birmingham tramways company had dropped

their Bill entirely on account of being unable to get the clause omittted. In America they thoroughly recognised the principle that the roadways were first of all for traffic, and that when the interest of traffic clashed with the interest of people who used the roadways for other purposes, the former must prevail.

Mr. Russell wished to know the weight of the Thomson-Houston cars.

Discussion adjourned.

LEGAL INTELLIGENCE.

LANE FOX v. KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY, LIMITED.

This was an action (before Mr. Justice A. L. Smith, sitting for Mr. Justice Romer) to restrain the defendants from infringing the plaintiff's patent, No. 3,988 of 1878, for "improvements in obtaining light by electricity, and in distributing and regulating the electric currents for the same, and in the means and apparatus employed therein." The trial of the action lasted 15 days, and on Friday, March 18, his Lordship took time to consider his judgment.

The Attorney-General (Sir R. Webster), Mr. Moulton, Q.C., and Mr. J. C. Graham were for the plaintiff; and Sir Horace Davey, Q.C., Mr. Finlay, Q.C., and Mr. Roger Wallace for the defendants.

Mr. Justice A. L. Smith, on Wednesday, delivered judgment as follows: This is an action brought by Mr. St. George Lane Fox, an electrician of high repute, to test the validity of a patent taken out by him on October 9, 1878. The plaintiff alleges that he then hit upon the idea that by utilising secondary batteries, as invented by Planté, and coupling them up to the mains which conveyed the E M.F. in his system of distribution of electricity, such force could be kept constant in the mains, and thus an even, steady light would be had in incandescent lamps, which otherwise would not be. The Attorney-General designated this invention as being one to keep a constant potential at the lamps with a "variable load." It has been proved that the system of distribution of electric current for incandescent lighting in conjunction with the use of secondary batteries by reservoirs was a novel and valuable suggestion which has aided the perfecting of that science which has culminated in the incandescent lighting of the present day, and it certainly appears to me that if the plaintiff did invent and carry to a practical result what is now claimed for him, he is an inventor of very great merit. Some 10 years prior to the year 1878 Gaston Planté had invented and brought into use what is known as a "secondary battery"—that is, a reservoir in which the electric current emanating from a generator could be stored. Daniell, my brother Grove, and Smee had also invented cells to act as accumulators of electric energy, and these were in common use in telegraphy and other electrical work. The use of switches was also well known. They were means by which an electric current could be turned on or off, whether into or out of an accumulator, or in some other circumstances in which it was desired to turn on or off the electric current. Prof. Forbes told me that switches were as commonly used in electricity as water taps in the distribution of water. This secondary battery of Planté consists of a number of cells joined together, each cell holding sulphuric acid, in which are immersed plates of lead rendered porous and oxidised by a process fully described by him. These secondary batteries had before 1878 been used for the storage of electric energy, and utilised, among other things, for the ringing of bells or kindling lights, the energy then wanted being let out of the secondary battery by the pressure of a button, as is well known to many. Prior to 1878, attempts had been made at lighting by electricity, the means adopted being to place arc lamps into what is called series—that is, into line—and to pass the electric current through each lamp, and thence to what is known as "earth." This system, though suitable to the lighting of lamps in streets and such like, was not adapted to the lighting of the interior of houses and other buildings, as is now done by incandescent lighting, and, to use the words of Sir Frederick Bramwell, a director of the defendant company, "The great question of the day was the distribution of electric light." In this state of circumstances the plaintiff took out his patent of October 9, 1878. In it, among other things, he sought to bring about a distribution of the electric current, or, in other words, to divide the main current into a number of small currents branching off from them, so that by placing his lamps into what is called parallel—that is, at the side of the main current instead of in a line with it- each lamp might be fed by a small current which, when it had performed its mission at the lamps and exhausted its energy, or, in technical language, had reached zero potential, should pass on therefrom to earth. By this means of distribution of the electric current and the other means stated in the specification, the plaintiff designed to light, by incandescent lighting, towns and other inhabited districts. The name the Attorney-General gave to the proposed system was "the multiple parallel incandescent bridge." The plaintiff, as before stated, for the purpose of carrying out his proposal. determined to couple up the secondary batteries of Planté to his system of distribution. The complete specification, as it now stands, states that the purpose of so doing was to "distribute and regulate the electric current for obtaining light by electricity." The plaintiff's case is that by coupling secondary batteries to the mains the electric energy therein would flow from the mains into the batteries when the energy in the mains was above equilibrium, and also flow from the batteries into the mains when the energy therein was below equilibrium, and that thus a constant potential would be kept in the mains and the light in the lamps steady. The defendants, in the first place, assert that the specification shows that Planté batteries were resorted to by the plaintiff, not for the purpose, as he now states, of regulating the electric current, but for the purpose of storing up what E.M.F. might emanate from the generator when the load upon the main was light, or, in other words, when lamps were off, and of using such stored-up force when the load upon the mains became heavy—that is, when the lamps were on—or when the generator was not at work. They say that the present claim of the plaintiff as to using secondary batteries for regulating the electric current is not to be found in the complete specification as it originally stood, and that it is only rendered possible by an adroit amendment made therein in the year 1883, when the second disclaimer takes place. It becomes necessary to see what the complete specification did contain when filed on April 9, 1878. The Attorney-General, in opening the case, and again at the end of his reply, told me that if Mr. Lane Fox had now. in the year 1892, to sit down and rewrite a provisional and complete specification of his invention of 1878, with all his subsequent knowledge, he would write them again in the same words and the same form. This statement in reply somewhat stretched my credulity, seeing that he and Sir Horace Davey had occupied me for 15 days in trying this case, a very considerable portion of which had been taken up in discussing what the two documents meant. By the complete specification Mr. Lane Fox claimed for improvements in electric lighting by, amongst others, the six following means: 1. By means of the distribution of electric energy by means of branches and sub-branches. 2. By means of this distribution in conjunction with incandescent lamps. 3. By means of an apparatus for measuring electricity. 4. By means of the employment of secondary batteries as reservoirs in combination with his system of distribution. 5. By means of the use of a regulator and other mechanical mechanism wherewith to regulate the E.M.F. in the mains. 6. By means of mechanism wherewith to convey electric energy. On January 26, 1882, the plaintiff disclaimed his claim to his appliances wherewith to measure and to convey electric energy, and on July 30, 1883, he further disclaimed his claim to his distribution of the electric current, whether alone or in conjunction with the incandescent lamp, and also his claim to the regulation and other mechanism which I shall hereafter for the sake of brevity call the electrometer. It will be seen that all that was left of his patent, as the specification now stood, was his claim for distributing and regulating the electric current for obtaining light by electricity by means of the employment of secondary batteries as reservoirs of electricity in combination with a mode or system of distribution of electric energy. In the specification, after describing a lamp and the way of distributing the electric energy and the mains for measuring it, the plaintiff makes this statement: "The E.M.F. of the electric conducting mains should be kept as nearly as possible constant at, say, 100 volts of British Association units of E.M.F." The Attorney-General, in opening this case, stated that this mention of 100 volts showed the foresight of Mr. Lane Fox, for it was the pressure now universally adopted. This, upon the evidence, appears not to be so, nor does there seem to be any special virtue at all in having a pressure of 100 volts. Mr. Lane Fox then proceeds to deal with secondary batteries as follows: "A number of secondary batteries, such as Planté's (lead and sulphuric), such batteries being joined together in series between the main and the earth, will serve as a kind of reservoir for the electricity. The cells should have a very large conducting surface, and there should be several batteries connected up at several points of the mains, so that, by increasing the E.M.F. during the hours when not much electricity is being used, they will become charged, and the E.M.F. will be stored up in them, so that a sufficient supply will be available when the E.M.F. falls owing to the draft from the mains, when the force is most used and needed. The number of cells in each of these batteries will depend upon the E.M.F. of the mains." It is true that in the paragraph about secondary batteries Mr. Lane Fox does not mention anything about their being employed to keep the E.M.F. in the mains constant, but in another place he is explicit on the matter. He says: "In order to keep the E.M.F. constant, it is desirable to have, in the first place, several generating machines, also a number of reservoir batteries as before explained." He then goes on to disclose his electrometer. It was known to electricians of that time that, by reason of the resistance of the mains, the further the electric current travelled up them from the dynamo, the less was the potential in that current; in other words, that by reason of the resistance of the mains the further the lamps upon circuit were situated from the dynamo, the less illuminating power they received. This upon a long circuit was matter of moment. Anxious as I am to read the specification in favour of the patentee, I cannot do so without seeing that Mr. Lane Fox, when he drafted it in April, 1879, had in his mind, as regards the matter now in hand, two separate and distinct ideas. The one was that by coupling up secondary batteries to his system of distribution of electric current he might be able to neutralise the pressure of the mains, and then render constant the E.M.F. therein (this would be in aid of the dynamo, as Prof. Perry stated); the other was to regulate such E.M.F. in the mains (and this, as it seems to me, was for the benefit of the lamp). These ideas are separate and distinct. Prof. Forbes stated that his reading of the specification was that Mr. Lane Fox meant a constancy of the pressure all over and at all times. Mr. Lane Fox, in cross-examination upon his lecture delivered at the Royal Institution in 1882, stated to the same effect. In my judgment, the defendants are not correct when they state that Mr. Lane Fox by this specification only claimed the use of secondary batteries as re-

by these batteries he also claimed to keep the E.M.F. in the mains constant. I am against the defendants on this point. The defendants, however, say that if the specification is to be read as I read it—the patent is bad, because the complete specification as it now stands is not in conformity with the provisional. This point appears to me to be a formidable one for the plaintiff. It is unnecessary to go over the earlier cases cited by counsel on either side, for they are dealt with in the late case in the Court of Appeal of Nuttall *v.* Hargreave (L.R. (1892), 1 Ch., 23). The law is clear. It is this: A patentee must describe the nature of his invention in his provisional specification. He need not go into details, but he must describe, as I have said, the nature of his invention. In his complete specification when going into detail he must describe the same invention; if not, the patent is bad. Now, what has Mr. Lane Fox done here? In his provisional specification he states: "The E.M.F. for the electric conducting mains should be kept as nearly as possible constant at, say, 100 volts of British Association units of E.M.F. A number of Planté's (lead and sulphuric acid) cells joined together in series between the main and the earth will serve as a kind of reservoir for the electricity. In order to keep the E.M.F. in the mains constant it is desirable to have in the first place several generating machines." It must be noted that he does not here state that secondary batteries are available for this constancy as in his complete specification he does, but proposes that the generators should keep the E.M.F. constant and not even in conjunction with the secondary batteries. He then goes on to state that it is necessary to have the electrometer for the purpose of regulating the E.M.F. This provisional specification, reading it most favourably for the plaintiff, can only be read to claim for the invention of using secondary batteries, the keeping of the E.M.F. constant. I have no doubt that in the complete specification, as originally filed in April, 1879, the words "regulating the electric current" at page 3, line 16, and at page 5, line 44, were solely applied to the electrometer. What has been done in this? Upon disclaiming the electrometer on July 30, 1883, four years after the complete specification, it was sought to apply the words "regulating the electric current," which had been theretofore solely applicable to the electrometer, to secondary batteries so as to claim for them not only the power of keeping the force constant in the mains but of regulating it therein. The question is, does the plaintiff now claim for the same invention in his complete specification as it stands as he did in his provisional specification? I say he does not. In the provisional specification he claimed as his invention the use of secondary batteries in aid of the dynamo to keep the E.M.F. in the mains constant, whereas he now, by his amendment of his complete specification, claims as his invention the use of secondary batteries, not only to keep the E.M.F. constant in the mains in aid of the dynamo, but also to regulate the E.M.F. in the mains for the benefit of the lamps. The case is this. In the provisional specification he claimed by his use of secondary batteries invention X, in the provisional specification he further claimed by the use of the electrometer invention Y. In the complete specification he now claims by the use of the secondary batteries inventions X plus Y. How can it be said that he now claims in the complete specification the same invention as he did in the provisional unless X and Y are the same invention, which in my judgment they are not? And what is more, the evidence leads me to conclude that secondary batteries when coupled up to a main will, under certain conditions, bring about some of the regulation force originally claimed for them. The eminent electricians called by the plaintiff, in conjunction with those called by the defendants, have satisfied me that in some circumstances, especially when fully charged, secondary batteries coupled to the plaintiff's system of distribution have an inherent power of regulating the E.M.F. in the mains, but the amount and value of such power was a matter of dispute. The evidence shows that the batteries, automatically worked, will not keep the E.M.F., in the mains constant. As to the power of regulation, Prof. Perry stated that the compensating effect was a very important one, and that the advantage of the patent was to prevent flickering. The plaintiff declared this invention was a departure from many of the things written before 1878, and, as regards that part of his invention for distributing electric current, together with coupling up of secondary batteries to the mains, I think this may be so. Prof. Silvanus Thompson stated that with batteries so placed the regulating effect was a necessary consequence. Prof. Barrett also stated that secondary batteries, he knew, would operate to bring about a constant pressure, and Prof. Forbes said that they had the regulating effect spoken of by the witnesses, and he added, "I have always considered secondary batteries most essential for steadiness of light," and went so far as to say that he had never seen steady light without secondary batteries He then alluded to the lights of the court in which I was sitting and for which no secondary batteries are used, and told me that the lights were varying from 15 to 20 volts. In my judgment, if this was so, for all practical purposes the light was an even and steady one, and as good as could be desired. The witnesses called for the defendants did not deny that secondary batteries had some regulating effect. Sir Frederick Bramwell said: "I think they may be acting as regulators in part. I think the batteries would help to maintain the constant pressure at the mains. I think the secondary batteries would tend largely to correct the rise and fall of voltage where lamps were turned on and off. The batteries would maintain, or tend to maintain, a constant E.M.F. at the lamps." He also stated that they could not be used automatically. Dr. Hopkinson, upon this point, stated that secondary batteries would always diminish the flicker. If there were a flicker they would have exactly the same effect with a steam engine as with a gas engine. If the batteries were taken away, there would be absolutely no difference upon the pressure in the mains There are scores of stations without batteries. Mr. Crompton stated that secondary batteries with switches remaining constant did not tend at all to diminish flicker. Mr. Miller, the resident engineer at Kensington Court station (the defendants' station), stated that secondary batteries do not automatically regulate the potential, although he said in cross-examination, if there be a change of pressure in the mains the secondary battery minimises the effect. Mr. Swinburne declared you could not use secondary batteries for storage so as to be of use against flickering. Mr. Kennedy, the civil engineer, who had made tests wholly unconnected with this action, produced them to explain the extent that regulation by a secondary battery was capable of, and he stated that a secondary battery would help in regulating small variations, and he adds: "For very small variations such as continually take place in a circuit with many lamps, the secondary batteries will help to steady the lights; they do not keep the pressure constant." Mr. Drake, who has been working practically at batteries since 1884, and has had hundreds of batteries under his charge, and who was, to my mind, a particularly intelligent witness, stated: "There is a prevention of flicker by use of secondary batteries if fully charged, even though the motive force be a steam engine and dynamo." That is, if the actions are very quick, if a few lamps are shut off, in a small system, so that the shutting off of a few lamps affects the light, the secondary batteries would help to regulate, but only for a few moments. And Mr. King, who had had great practical experience in manufacturing secondary batteries since 1883 and had made upwards of 38 new experiments in charging and discharging them, stated, in cross-examination: "I will swear that there would be no more variation (that is, in the voltage in the mains) with secondary batteries than without them. I say the secondary batteries, the current running constant, tend to cause a variation rather than diminish it." It was proved that many installations were worked without the application of the secondary batteries at all, the Law Courts being amongst the number, and, as before stated, Dr. Hopkinson deposed to scores of stations existing without secondary batteries. It is true the secondary batteries are extensively used, though obviously by no means universally. Mr. Drake told me that he was connected with about 250 installations of incandescent lighting, of which about one-third had no secondary batteries and the other two-thirds had. He had also stated, and I have no reason to doubt him, that the object of using secondary batteries was to serve as reservoirs, to enable the engine to be stopped and yet to have the incandescent lighting continued from the motive force stored up in the batteries. In cross-examination he said that he had some batteries on with dynamos going, but that he charged them by day and worked them off by night. Sir Frederick Bramwell, Mr. Crompton, and others, gave strong evidence that the principal use of secondary batteries was as reservoirs, and this appears to me to be the case. Scientific evidence was given to show what was the real rise and fall of voltage in the batteries and mains upon the application or withdrawal of the E.M.F. therefrom. This evidence was illustrated by diagrams which it would be impossible to reproduce here. In my judgment the plaintiff, as to the controlling effect of secondary batteries, has placed his case too high, and the real truth is that if there be a short, quick flicker at a lamp a secondary battery coupled up with the main will at times help to diminish it; but that secondary batteries as designed to be used by the plaintiff—that is, without mechanical and manual services—will not bring about the constancy of pressure which the plaintiff claimed for them in his original specification. The result of the evidence upon this head I may, I think, accurately sum up in the words of an article in the *Engineer* newspaper of December 26, 1890, which the Attorney-General used largely in cross-examination of the defendants' witnesses. Mr. Crompton, Mr. Miller, and Mr. Kennedy said that the words were fairly accurate. They are as follows: "One of the advantages found by having more than one pair of batteries attached to the system at points totally wide apart is that the effect of the regulating movement of switching in an extra cell would show a difference of two volts on the lamps is partly neutralised by the distant battery." Mr. Lane Fox, in his declaration made in March, 1883, stated that the effect of the change of about one volt upon a lamp was practically nothing; and if Prof. Forbes was correct in stating that there was a change of from 15 to 20 volts in my court, it is obvious that a 2-volt change is of little importance. The Board of Trade sanction a change of four volts up and four volts down. In my opinion the point taken by the defendants is fatal to the plaintiff's case, and the specification as it now stands does not claim the same invention as the provisional. I might stop here, but as others may not agree with me I shall give judgment also upon some of the other points raised. His Lordship dealt with the other points of the case at great length, and reviewed the authorities, and concluded as follows: I have now held that the patent is bad upon the ground that the complete specification does not conform to the provisional; upon the ground that the invention as described cannot be made to work, and also upon the ground that if it could no sufficient information is given as to how it was to be made to work; and I have stated my reasons fully for so holding. It is not necessary to give any further judgment in the case, but had the plaintiff been able to surmount the above difficulties, and had he established that by his invention he could have brought about what the Attorney-General said he could, my judgment would have been that his invention was the subject-matter of a patent, that it had not been anticipated, and that the defendants had infringed it. I give judgment for the defendants with costs.

COMPANIES' MEETINGS.

LONDON ELECTRIC SUPPLY CORPORATION.

The fifth ordinary general meeting of this Corporation was held at the Cannon-street Hotel on Friday morning, 25th ult., the Chairman (Mr. James Staats Forbes) presiding.

The **Secretary** and **Manager** (Mr. Charles B. Waller) having read the notice convening the meeting,

The **Chairman** said he presumed the report (published in last week's *Electrical Engineer*) would be taken as read. Shareholders having signified their assent, he asked for their consideration, as he had been suffering from a bad throat, and was afraid his voice was a little weak. A good deal of his life had been passed in trying to make the best of a bad business, and that was what he had to do then. He had been trying to satisfy his own mind—people said no one could inspire belief in others unless they believed in themselves—and to find out from the figures in the accounts and from the report whether there was really any ground for despair, or whether there was ground for hope. And he had solved the matter on the figures themselves by resorting to that wonderful qualifying thing, the "if." He did not know that he could put it (the actual condition of things) before them more graphically or more truly than by saying that if something hadn't happened which had happened, the state of affairs would have been that, instead of meeting to deplore a loss, they would have met to pronounce a profit. If they would kindly turn to the revenue account, which was the essence of the whole business, he would present that proposition to them in the figures. They would see there that the total outlay for the year was £22,517. 19s. 7d., and that the total receipts had been £15,560. 17s. 11d. Therefore there was a loss by balance of £6,957, which showed exactly the money that had been spent in excess of what had been received. And then there was his "if." Why was this? In 1890 their receipts were £28,684, in 1891 they were only £15,560. If in the interval the calamities of the Company had not led to a great number of consumers who were customers in 1890 leaving them altogether, and so reducing the income for the year by £13,124, their position, of course, would have been very different. In 1890 the expenses were £28,704, and in 1891 £22,517, and that accounted for the greater part of the £6,900 adverse balance. It came really to this, that if they had remained in the position they ended 1890 in, they would have had a profit instead of a loss, and the difference would have been exactly in that shape which was so agreeable when it was in the right direction, and so adverse and disagreeable when in the wrong direction, because the £6,000 odd of profit was turned into that amount of loss, making, of course, £12,000 to the bad. This was really the long and the short of the business. The reason why they had got into this position in the current year they were already possessed of, because in March last, when they met to deal with the accounts of 1890, that calamity had already occurred—viz., the fire at the Grosvenor—which suspended their business between November and February, and suspension of their business, of course, took away the greater part of the customers which were lighted up to the date of the fire. Perhaps he had better illustrate the operation of it (the calamity) by figures. On November 15, 1890, the date of the Grosvenor fire, they had 312 customers with 38,272 lights. The fire came, the whole thing collapsed, and for many weeks there was no supply at all. It was not until February of the year 1891 that they were able to begin to light. The change of circumstances was such that instead of having 38,272 lights to light up, they had only 9,000, but that 9,000 had been growing from day to day almost, certainly from month to month, ever since. On February 15, 1891, having had that long interregnum, the Board devoted themselves and the ability of all the engineers and advisers they had, to start the thing upon something like a permanent basis. Shareholders knew that they had to remove the machinery from the Grosvenor station to Deptford, so that the latter might supersede the former. A good deal of time was occupied, and a good deal of money spent on this, and they started in February with the belief that at all events they had got a machine that would run. But they had to begin with 9,000 lights, and that number had increased by slow steps until it had reached, on March 22, 1892, 36,463, so that they had taken, as it were, the whole year to overtake the number of customers who had lights when the disastrous fire took place in November, 1890. Unfortunately, the anticipations of the engineers upon which the Board founded their expectations were not realised to the full, because, although it became an ascertained fact that current could be generated at Deptford, and could be transmitted to London and there redistributed to the consumer, they had not attained in the first period of that experiment that perfection of the parts upon which efficiency depended, and they suffered the same kind of disaster which very often befell experiments: the theory was right enough, but in practice it was not quite so efficient as it might be—and that was their experience. After they had started that thing, and after people began to come back to them, they had casualties, breaks down of the mains, of the transformers, of the dynamos, interruptions of the light, and so forth. And a very serious calamity of that sort occurred in the month of November, when from that curious coincidence of causes which it was impossible to trace—of course, there must be a cause, but a cause beyond any electrician or engineer he had been able to meet—the whole thing came to collapse: dynamos went wrong, mains went wrong, everything went wrong, and for four days or more they were without light. There was in a lesser degree what had taken place when the Grosvenor fire occurred. They had worked up their customers. Then came their disasters, and down the numbers went again; and of course not only did the numbers go down, but people who had not contracted to take the current from that Company were alarmed. Some clubs and other people went off. Now that would account for the state of the balance-sheet at the end of the year—a year which only commenced in the middle of February, and which had in itself the elements of such drawbacks arising from the accidents and breakdowns mentioned, as to seriously retard the progress of the business, and, in fact, to diminish the number of customers who from time to time had been induced to come on their circuit. That was where they were, and that was why the income, instead of being what it would have been if they had started the year with the same number of people as when the Grosvenor broke down, had diminished. But if the income had decreased the expenses had not. The fixed charges were really not in the least affected by the number of lamps they were lighting. This really accounted for the exceedingly unpleasant result of the year's working. There was, however, one item which could not be carried to the profit and loss account, and that was the value of the experience gained during the year. They were very anxious that the proprietors of that undertaking should know as much about it as the Board did themselves. In the last two preceding reports, therefore, they were very careful to have in black and white from the engineer of the Company (Mr. Ferranti) his views in unmistakable language as to the position of that experiment; and the most that could be said about Mr. Ferranti's views was that they were somewhat too sanguine. But it looked very much as if the experience of these breakdowns had led them to believe that they were only too sanguine, and not wrong in principle. Because it might be interesting to know that these various accidents to the dynamos, and interruptions of the mains, and the transformers beginning in a very considerable ratio in the early months, diminished in the latter months of the year to zero. It came to this: that the theory being right, the application or adjustment of the parts being novel, and at the same time a very delicate operation, had to be made not in a drawing or on paper, or as an abstract proposition, but had to be felt out in practice. When London was blessed with a fog of not only great density but prolonged endurance for four or five days and nights, their machinery at Deptford ran in the most perfect manner. There was no hitch or halt during all those hours. It was maintained at full pressure during that time and ran to perfection. However, to sum up, they opened the year with an amount of experience as to the probabilities of this system which represented a very large value. Of course he need hardly say that the Board-room of that Company during those many months had not been altogether a bed of roses. He dared to say it would be as satisfactory for them to hear as it was for him to tell them after the difficulties they had passed through and the experience they had had (he spoke in the presence of most competent judges), that they thought it was possible to develop that system of high tension to an extent and at a cost which, notwithstanding the bad start and the losses resulting from entering upon novel experiments, would eventually land the Company in a satisfactory position. He did not know whether they would like him to go into much more detail. The report of the engineer was given at some length, and that was probably more worthy of their careful study than any remarks he had to make, or anything in the body of the report. For the sake of being in order, however, he would go through the paragraphs in the report. With reference to the remark therein that the extension of electric lighting had been less rapid than was anticipated – but the light was undoubtedly growing in public favour—he said that in their case he was not surprised at this, for the reason that they had had these breakdowns and interruptions. Their customers left them and they lost their character, and to some extent their market. This was what was on the cards for people who left beaten paths and followed new ones. They need not be very much distressed if they made a loss for the first year or two, because he remembered a company connected with electric supply which for several years showed year by year a heavy loss on the working. But the progress of that company had been such that all the loss had since been wiped out of profits, and for many years large dividends had been paid. He did not want to be a prophet, but it was quite on the cards that this might be the case with the London Electric Supply Corporation. He was afraid shareholders would never get away from this, that the experiment would sooner or later have cost them a good deal of money, which in their present stage of experience might have been saved. Of course that was quite obvious. The people who came after the pioneer had a comparatively easy road; they had the benefit of all his mistakes. They (the London Electric) happened to be pioneers, they ran the risks, and might have secured the profits of a great invention. Steps were being taken by which the cost of producing the current would be materially diminished. They had made some advances in that respect already. The expenses of that year had been reduced by £6,000, and they were susceptible of still greater diminution. Suppose they doubled the output this year, the expenses would not be doubled, and would only be very slightly increased by the additional driving force required—coal, water, and oil. All the fixed charges would remain exactly where they were. This was why the outlook was rather better than might be induced from a superficial study of the accounts, or the application of ordinary knowledge to them. Every new subscriber now meant nearly the whole of the subscription as additional profit. If they had had a larger number of subscribers, they would have been £6,000 to the good instead of to the bad. The Board believed they could assure shareholders that they were more confident now than they were at the start of the year that this thing was to be realised. As to the accounts, he would be happy to answer any questions upon points of detail, but there was one matter he ought to mention which concerned the future. Referring to

would see there 111,000 ordinary shares of £5, that was £555,000, paid up. Then £250,000 worth of preference shares had been created and used, and they were practically paid up, except for some calls in arrear. Then as to borrowing powers, the Directors might, by the articles of association, borrow upon their own discretion not exceeding £250,000. If they wanted more, they must go to the proprietors to have their deeds ratified. But of course discreet directors did not avail themselves of powers of that sort without taking proprietors into their confidence and having their concurrence; and when the moment came that they would have to deal with borrowing, they would certainly take the proprietors into their confidence. That would not be very long; it would be at that meeting. The capital account was very interesting, inasmuch as it dealt with a vast number of items, and carried these forward from year to year in order that some day or other when the local authority took over that Company's undertaking they might have data as to how the capital had been spent. The revenue account was also very full. How did they propose to carry on? They had spent all their money, and they had only partially developed the business. Well, the present machinery, upon which they had staked their fortunes, consisted of two parts: (1) that which was now at work, and (2) that which had been constructed more or less on the theory that it would be brought into work. They had had to stop any further expenditure than had already been incurred upon No. 2, because they had come to the conviction that they had better perfect and found the business upon that part of the machinery which was in work before they proceeded further. That machinery, existing at that moment at Deptford, was capable of lighting 90,000 lamps. He said "capable of lighting"; that was when those drawbacks arising from a little want of skill and of knowledge in the adjustment of the machines were all conquered—and they were being rapidly conquered. They had climbed down a little from the heights, and determined that their policy was not to move further until they had secured the above number of lights, and shareholders would see how different their position would be with 90,000 instead of 36,000 lights. They had not got quite enough money to carry out that programme. They were in debt—not very largely; £20,000 would cover all. He was sorry to say, moreover, that the bulk of the liability arose owing to the second part of their enterprise—viz., the construction of two 10,000-h.p. dynamos. They had spent a great deal of money on these, and there were certain claims due on them which they must pay. They wanted a little working capital — besides paying off the £20,000 of indebtedness—to have enough money in hand to develop the existing machinery, and carry it to that state of efficiency which would enable them to light 80,000 or 90.000 lights, as the case might be. They had no money, and it was vital to them to get it, but how? With a balance-sheet like theirs, with shares at a discount, and a good many friends out-of-doors ready to pronounce disaster, it was not an easy thing to raise money. Therefore, instead of thinking of issuing debentures, they had arranged, subject to the concurrence of shareholders, to have a loan. There was one peculiarity about that Company which he thought took it a little out of the ordinary category. Whether the venture in which they were all engaged was carried to a successful issue or not, the preponderating investment in that Company was the investment of the Directors and their friends. They held amongst them two-thirds of the entire paid-up capital, and he had often heard it said that the great guarantee of the success of a joint-stock company was that the directors themselves should hold largely in it. If that were so, he knew of no joint-stock company in all his experience where the directors held such an enormous proportion of the ordinary capital of the company. That being so, it was a very fortunate thing that in the position of the Company, looking at the unwisdom of attempting to issue debentures under present conditions, one of their own Directors should be ready to find the £50,000 which they wanted, for a term of three years, with the option of discharging it at their convenience within that time, at 5 per cent. He knew of very few companies which would find a director to come forward and put himself in that position. He thought the service was a twofold one. It not only relieved the Company of the possibility of very bad financial arrangements, but showed the confidence of the Director in his own property, because he happened to be the largest shareholder in the Company. He would not mention the name of that Director, because his modesty might be disturbed; but he thought the position of that Director and his readiness to find money for the Company was an indication at all events of a confidence in it which he hoped would be catching and keep the proprietors in good spirits. One thing he must tell them. They had better appreciate it, because in a matter of that sort even remote possibilities must be considered. That Director would not lend his money except on a mortgage, and that mortgage would be drawn by his legal advisers, and would provide remedies in the event of certain things. That loan was for three years, and if at the end of the three years the Company could not meet it, there would be a right of foreclosure. But this attached to every mortgage and to debentures themselves. He would not have thought it necessary to allude to this matter, but for the conscientious scruples of the Director, who thought it ought to be understood that, although he came forward in that liberal and handsome manner to help the Company then, he was not therefore to be precluded from the ordinary remedies of a creditor at the end of the term if the accounts were not paid. To sum it all up, if they could not pull this Company out of its troubles long before then (three years) they would have to consider what was to be done with it. But, humanly speaking, with the experience they had had, and with most of the difficulties overcome, there seemed little reason to doubt that long before three years had expired they would be able to issue debentures, or make other financial arrangements of such a character as would enable them to discharge that loan without any of the terrors which he had indicated happening. That being all he proposed to say, unless in answer to questions, he begged to move the adoption and approval of the report and accounts.

This was seconded by **Lord Wantage**.

Mr. Praed asked questions as to their liabilities, how many lights were being supplied at that time, and at what pressure the current was being transmitted to London? He hoped the Board were satisfied that the present dynamos would light 90,000 lamps, and that the money expended on the 10,000-h.p. dynamos had not been thrown away, and that they would come in useful.

The **Chairman** said that on the 22nd March they had 423 customers with 36,463 lamps lighted, and they had 26 customers waiting for 3,143 lamps, so that practically they had secured 40,000 lights. They were transmitting at 10,000 volts, and this transmission had caused them some trouble and expense in the early part of the year. But the experience gained had removed from their minds what at one time rather disturbed them—viz., the fear whether that voltage could be maintained. As to the 10,000-h.p. dynamos, a large expenditure had been incurred on them, but was now suspended until the completion and perfection of the other business (getting 90,000 lights). Whether or not they would conclude in the future to carry on that experiment (the big dynamos), for it was a great experiment, he did not know. Of course, having spent so large a sum, having built an enormous place for the purpose of developing those dynamos, it would be, not a calamity, perhaps, but a serious drawback to the Company if that outlay were in vain. The prevailing opinion of electricians was, however, that small units were more convenient and economical than large ones. They sprung from 625-h.p. dynamos to 1,250 h.p., and had had some trouble in getting the latter to go at 10,000 volts, but they thought they had overcome the difficulties. Assuming a sufficient demand for light, these were highly economical and very advantageous, but they had some drawbacks. For instance, unless they were working at full load, it was like using a Nasmyth hammer to crack a nut, or employing eight horses to pull a gig. Instead of developing big machines, they might find the multiplication of small units the better plan. At present the money laid out in the 10,000-h.p. dynamos was lying derelict. As to the questions about indebtedness, he would be glad if Mr. Praed would call at the office when the matter could be explained. To this Mr. Praed assented.

Mr. Adams asked as to the loan of £50,000, was the security to be a mortgage on the whole of their property, as if their assets were worth anything like the proper valuation, the security seemed very good?

The **Chairman**: Naturally a mortgage was on the whole of the property. There were two aspects of the question. There was the property as it stood in the capital account of the Company, and there was its realisable value, supposing the Company was to break down. If the earning capacity of the Company had not developed at the end of three years to such an extent as would justify someone in lending £50,000 or the issue of debentures to that extent, it must be in a parlous state. He bought the other day in London for £20,000 a property which cost £140,000, that was for a company with which he was connected. The company owning the property had broken down, but he did not think theirs was going to break down. Naturally, however, a mortgagee would take everything he could get into his net.

Mr. Hill asked if the Board were sure this £50,000 was all the money that was necessary to try that pioneer experiment to the bitter end, because it must be plain that if they borrowed that money on a mortgage of their entire property they would be unable to borrow any more?

The **Chairman**: The Board had taken infinite pains to see what moneys would be required to perfect the present establishment up to an output of from 85,000 to 90,000 lights, and they were satisfied that the amount named would be enough. They did not anticipate any calamity arising to disappoint that expectation, but they would know probably within that year whether they could or could not materially increase the sale output.

Mr. Kisch thought the Board must allow that shareholders had shown exemplary confidence in the Board, as well as patience, after all they had gone through. They had met year after year to hear reports which on their face were by no means satisfactory, and had hopeful and encouraging statements from the Chairman. They met now, after four or five years of existence, with a report which the Chairman had practically admitted was less hopeful than ever. The Chairman was good enough to say that the only encouragement he could give was that if certain things had been different from what they were the results would have been different. The whole of the £250,000 paid to the late company (the Grosvenor) appeared practically to have been paid for nothing. They had to face the fact that the whole of their property might be swept away to satisfy a comparatively small sum like £50,000. Mr. Kisch then turned to the accounts, and compared the revenue for the last year with that for the year before, to the detriment of the former. He also adversely criticised the expenditure. They had been told all along that their present plant was intended to supply up to 90,000 lights, and certainly, until he came into the room, he had not the least idea that any further capital would be asked for, except to supply a number in excess of this. He then proceeded to question the holding of the Directors who signed the articles of association; suggested that the accountant was interested in a firm from which the Company purchased a large amount of goods? The Company was over-officered, and this showed it. He wanted to know whether all orders for electrical stores and appliances passed, as they ought, through the

engineer-in-chief? He believed that they did not, and that the power for such purchases was vested chiefly in the accountant. He would like to know how the appeal against an injunction which was then before the Courts was likely to affect them if the injunction was sustained?

The **Chairman**, with some indignation, asked why Mr. Kisch had not put his accusation in form and supported it by evidence? Why did he lend his ears to rumours of that foul kind? For his part he did not believe a word of it. As to his suggestion that the purchase of stores was left to take its chance, he could say something definite. On the contrary, no stores were purchased in that Company that were not remitted to a special meeting of the Directors in committee, and as far as possible everything was got on tender from the best firms, and no officer in the Company had the slightest voice in those tenders. As to his general suggestions, what alternative had he got? He agreed that the last year had been disastrous, and he (the speaker) supposed Mr. Kisch knew the reasons why the thing had broken down. But misfortunes were only redeemed by knowledge and courage to overcome them. If the Board looked on the future of the Company as so hopeless as Mr. Kisch seemed to think, they would come to the shareholders and tell them so, and advise them to stop it at once, to wind up and get rid of it. But they believed it could be redeemed, but only by people who had solid information and a clear conception of remedies for patent faults, not by mere talk. He and his colleagues would be delighted to meet any honourable proprietor at the office by appointment to discuss remedies, which they believed were sticking to the Company, and perfecting the machinery up to 90,000 lights. If that were achieved, as they believed it could, they were all satisfied that the position of that Company would be greatly altered. Of course if shareholders were going to throw up the sponge that was their business, but it was not the temper of the Board, and they were not going to recommend them to do so Mr. Kisch had blamed him for being sanguine. Why! the world was not carried on by wet blankets. Had he any suggestion to make? Would he kindly say how during the current year that balance-sheet could be turned from a loss into a profit? If he would satisfy them that such a thing was possible he (the Chairman) could only say that the Board would embrace him most willingly and cordially. But he gathered nothing from Mr. Kisch's speech.

Mr. Kisch said he was going to move, as an amendment, that a small committee of shareholders should be appointed to confer with the Board, with a view to reducing the expenditure, and to report as to the possibility of bringing the Company into a solvent and paying condition. (Several shareholders expressed their dissent from this proposition.)

The **Chairman** did not want to send Mr. Kisch away dissatisfied, and proceeded to argue from the figures representing customers and lights before the Grosvenor fire took place and after, that if the fire had not occurred, and if their business had progressed in the same ratio as it was progressing, instead of having 36,000 lights they would have had 60 000. What they had got to do was to show that their system could be run, and then more customers and lights would follow as surely as night followed day. He did not know whether a committee found favour with shareholders? (Cries of "No, no!")

A **Shareholder** remarked that they had conducted this experiment by means of an eminent engineer—Mr. Ferranti. Had they abandoned him, or had they still access to him for advice?

The **Chairman**: Since an honourable proprietor put the question he was bound to answer it. He had hoped the name of Mr. Ferranti would not have been brought up. Mr. Ferranti had an agreement with the Company which expired. He was the engineer, the contractor, and also the inventor and patentee of the Company. When that agreement came to an end by effluxion of time, the Board did not think it desirable to continue Mr. Ferranti in these positions, which were found to be conflicting to the interests of the Company, as the Directors thought. Therefore, being quite satisfied that Mr. Ferranti was not indispensable, they let the agreement take its course. It did not expire, however, without their taking measures to carry on their business, and he dared say that if they wanted Mr. Ferranti's advice they could get it. But they did not think it desirable to retain him at a high remuneration when the work of construction, for which he had been retained, had come to an end.

A **Shareholder** asked as to the injunction?

The **Chairman** said that whether the appeal was or was not dismissed, it would not be material to the Company.

Another **Shareholder** said he would have the courage to second the amendment of Mr. Kisch. He was satisfied that if ever confidence was to be restored in the management of that Company, it could only be done by an independent enquiry such as was proposed. He had listened with attention to the Chairman's statement, and a very able one it was; but running through the whole of that statement were remarks that various accidents had happened, and many misfortunes had befallen the Company. He did not hear, however, who was responsible for these, which had diminished the value of the Company to one-fifth of what it was before. Surely the Directors were to some extent responsible for these disasters. They were going to ask shareholders to mortgage the whole property, representing nominally half-a-million, for £50,000. He thought they should know whether there was any chance of carrying on the Company at a profit if the £50,000 was obtained. He wanted to know why they were to suppose that the Directors would profit by the experience gained in the future more than in the past, for they had been trying these experiments for four years?

Sir Thomas Bazeley said it seemed to him that if the Directors were not capable of deciding the point, the works had better be closed at once. He himself had been opposed to high-voltage transmission, but the more he saw of it the better he liked it. He would like to call attention to the management expenses. No one could look at the accounts without being struck by the fact that the balance which signified loss was almost covered by management expenses. When they had £3,000 for salaries of secretary, engineers, accountant, etc., with general establishment charges besides, and then Directors' remuneration, it struck him as a large amount. Were they in that respect really upon the most economical footing? The Board knew better than he did, but he thought the matter deserved their careful enquiry. The Board was not one to be overhauled in the ordinary manner. It was composed of men of high position and scientific attainments. He thought the action of the Directors in giving £250,000 for the Grosvenor was a little precipitate. However, he would not suggest a course to them, but he would relate an incident. Many years ago he was associated with an industrial company in low water, which had since become a sound dividend-paying concern. The Directors, during the low-water period, did not relinquish their fees, but agreed to postpone them till the Company prospered.

The **Chairman** asked if it was the pleasure of shareholders that a committee should be appointed to confer with the Directors, and put Mr. Kisch's amendment, for which only the mover and seconder voted. It was therefore lost, and the Chairman expressed the opinion that the meeting had come to a sound conclusion. He was glad to have had the views of the last speaker (Sir Thomas Bazeley), as he was most competent to judge of business of that kind. He was happy to hear that he did not despair of the ultimate success of high voltage. Who was to be the scapegoat for the present state of things he did not know. He himself had nothing to do with the policy of high tension. He came in rather to administer. The Board did naturally rely upon the scientists, who seemed to have been clever enough to produce arguments to satisfy some very hard-headed men of business, and get them to adopt and carry out their ideas. He supposed one of their greatest misfortunes had been that Mr. Ferranti's ideas, however clever, however sound, had not been realised quite as rapidly or to the extent that he thought they would be. The Directors certainly were responsible to the extent of having to lean in such matters upon the opinion of scientists to make a selection and to do the best with the thing they undertook. That about measured their responsibility. He thought they must go on with the Company and make the best of it. As to the remarks of Sir Thomas Bazeley on the establishment charges, he admitted that in proportion to the results they were very large. On the other hand, in that business there was a large amount of work which did not appear on the surface, and from which there was no result for a long time. They might, however, rely on the matter having the full consideration of the Board, who were really most sincerely desirous of doing all that ought to be done in the interests of shareholders. Would Sir Thomas Bazeley like to come on the Board? (**Sir Thomas** said that he lived too far away,) because no doubt they would have a vacancy, and it was good to have a shareholder to deal with the problem of pulling that scientific experiment back into success. Committees were no good, though he had known them destroy some properties.

Sir Thomas Bazeley said he had had the pleasure of visiting the Company's works on the previous day, and was very much pleased with all he saw. He thought that if they could manage without breakdowns they ought to do so. He declined a directorship, however.

The **Chairman**: They had had a very pleasant discussion, and really the best thing they could do was to keep in good spirits and be friendly with each other. He would put the resolution that the report and accounts be adopted. This was carried *nem. dis.* He then announced that he was defunct, and vacated the chair in favour of Lord Wantage, who proceeded to propose the re-election of Mr. James S. Forbes and the Hon. Reginald Brougham as directors.

This was seconded by **Mr. Adams**, and carried unanimously.

Mr. Forbes thanked the meeting, and said that when he came into a thing of that sort he shared the blame with the utmost equanimity. Really, if he were not so deeply interested in it, if it was not so fascinatingly difficult, he would be glad to get out of it.

Mr. Brougham also returned thanks, remarking that he would be sorry to run away now that they were in a tight place.

Mr. Forbes, having resumed the chair, said that as to the loan he would like to ascertain, not by express resolution (there were other ways of making feeling known in a room), whether shareholders concurred in the arrangement he had mentioned. Was there anybody who dissented strongly to the proposed mortgage? In reply to suggestions and questions, he said that the mortgage must be on the whole property; that it was not desirable to issue debentures now, but that when the position of the Company had improved so far as to justify their issue on reasonable terms, it could be done, and the present loan could be included in the amount asked for. The £30,000 of working capital, over and above the £20,000 to pay off debts, which would be provided by the loan, would last until about the middle of next year.

A **Shareholder** pointed out that if debentures were issued now there was not the slightest chance of anyone taking them up, and he therefore thought they ought to be very grateful to the Director for the loan and accept the offer.

The **Chairman**: With that word of encouragement the Directors would take the responsibility of determining the matter, which they believed was greatly in the interest of the Company.

The re-election of the auditors, Messrs. Kemp, Ford, and Co., was unanimously agreed to; and the Chairman promised, at the request of a shareholder, that in future reports the usual practice

of printing the names of the Directors and officers for the time being should be followed.

The proceedings closed with a vote of thanks to the Chairman, who remarked that it was a great encouragement to have those handsome things said of one. It was more valuable than the money so kindly voted by shareholders.

INTERNATIONAL ELECTRIC SUBWAY COMPANY.

The statutory meeting of this Company was held at 12, King William-street, E.C., on Thursday, 24th inst., Mr. John L. Martin in the chair.

The **Chairman** said that under the advice of their solicitors they had completed the purchase of all the patents for the United Kingdom and Europe of the Johnstone system of underground electrical conduits. This system was extensively used in the United States, several hundred miles of the conduits being laid in New York, Chicago, and Philadelphia, and large contracts were, they understood, now being carried out in other of the principal cities of America. The system had been so extensively adopted in America because of its economy and permanency, that he did not think it was an exaggeration to say that it was the standard system of electrical conduits in use in America to-day. Their energetic Managing Director had secured the attendance at their offices of many engineers interested in electrical subway conduits from various parts of England, and had explained the system to them, with the result that they believed they were on the eve of obtaining large and substantial orders in various of the principal towns in England, and even within the precincts of London itself, and also in Paris. They had placed a full-sized model of their system in the Crystal Palace, where they understood it was exciting considerable interest. It should be borne in mind that their Company was really a pioneer syndicate, with a capital of only £25,000, and as their system became more widely known, the Directors believed they would be able to dispose of their rights on very favourable terms to the various European countries.

At an extraordinary meeting subsequently held, the Directors' remuneration was fixed at £250 per annum.

NOTTING HILL ELECTRIC LIGHT COMPANY.

The Directors' report to December 31, 1891, states that the expenditure on capital account amounts to £67,845. The Company commenced to supply current to consumers at the end of May, 1891; the revenue account, therefore, for a period of only seven months shows a debit balance of £617. 5s. 7d. The revenue account begins with a period of four months, during which most of the consumers were out of town, and but few houses were connected. The amount of electricity sold during the quarter ending December 31 was about four times as much as that of the previous quarter. The Company has constructed and laid 5¼ miles of culverts and pipes, into which have been placed 66 tons of copper strips and cable, the whole costing £26,794 6s. 8d., as shown in the capital account. These mains run past 445 houses, which can be supplied practically without further delay, and opposite to 331 additional houses, which can be supplied by simply crossing the roads. Of the 776 houses mentioned above only 77 were supplied by December 31, the number of lights installed being equivalent to 6,056 8-c.p. lamps. The Company has orders in hand for a further 560 8-c.p. lamps, and is now in negotiation for many more in connection with the existing mains. It may, therefore, fairly be reckoned that the increase during the current year will be very considerable. In the case of the neighbouring Kensington and Knightsbridge Company, the increase last year was 12,873 8-c.p. lamps, or 50 per cent. over the total of the previous year. The Directors have contracted for an extension of the mains southward into the Phillimore district, where a considerable number of householders have promised to take current, 14 houses having been already wired in anticipation. The cost of this extension will be paid for either by the issue of preference shares at par to the contractors, or by instalments which have been arranged for on terms convenient to the Company. A site for a battery station has also been secured in the Addison-road or S.W. district. The Directors propose to issue the remainder of the ordinary share capital in the form of 6 per cent. ordinary preference shares. The object of this issue is to enable the Company to extend its mains to further remunerative portions of its area, and it is the intention of the Directors to give the present shareholders the first opportunity of taking their proportion of these shares.

The fifth ordinary general meeting was held at Winchester House yesterday (Thursday), the chairman, Mr. Wm. Crookes, F.R.S., presiding.

The report and accounts were approved and adopted on the motion of the **Chairman**, seconded by **Mr. Franklin.**

COMPANIES' REPORTS.

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY.

Directors: Henry Ramié Beeton (chairman), Joaquin de Galindez, Robert Arthur Germaine, Robert Hammond (managing director), William Francis Leese, William Page. Secretary: H. St. John Winkworth.

Third annual report of the Directors, with balance-sheet, for the year ending December 31, 1891, to be presented to the shareholders at the ordinary general meeting to be held at the central station, Richmond-road, Kensington, on Tuesday next at 3 p.m.

The revenue account shows a credit balance of £2,250. 9s. 1d.; which, with the balance of £385. 15s. 8d., brought forward from the previous year, making a total of £2,636. 4s. 9d., is sufficient to cover

	£	s.	d.
Interest on £30,000 debentures	£1,706	0	0
10 per cent. to be written off preliminary expenses	542	9	9
Proposed dividend of 7 per cent. on £1,710 preference shares	113	9	7
Leaving a balance to be carried forward of	274	5	5
	£2,636	4	9

During the past year the business of the Company has steadily increased, the number of 35-watt lamps attached to the Company's circuits on the 1st January being 13,665, and on the 31st December 19,388. At the beginning of the year there were 248 houses connected, and at the end of the year 373. During the year a special unit of plant has been laid down, by means of which it is not only possible to supply a greater number of lamps, but the lighter load during the period of minimum consumption is more economically dealt with. Important extensions of the Company's mains have also been carried out. Since the end of the year the Directors have allotted £12,290 of 7 per cent. preference shares, bringing the total preference capital issued up to £14,000, out of the proceeds of which it is proposed to lay down further plant to enable the Company to cope with its increasing business, and, as the new business will probably entail but little addition to the standing charges, it may be confidently anticipated that the profits for the current year will show a substantial improvement on those of 1891. The following is a comparative statement for the past two years:

Working expenses. 1890. £ s. d.	1891. £ s. d.		Revenue. 1890. £ s. d.	1891. £ s. d.
1,921 0 7	3,118 2 9	Jan. 1 to June 30	1,373 6 7	3,838 0 6
2,703 5 10	2,889 12 5	July 1 to Dec. 31	*3,637 2 7	4,490 3 5
4,624 6 5	6,007 15 2	*Very foggy Dec.	5,010 9 2	8,328 3 11

An agreement, which, is hoped, will in future, provide a satisfactory addition to the profits earned at the West Brompton station, has been entered into with the Leeds and London Electrical Engineering Company, Limited, by which agreement that Company will carry on the business built up by the Company for the construction of central stations. The Directors have drawn no fees during the past year, but £200 has been paid to Mr. William Page for special services. The Directors congratulate the shareholders upon the promising position of the Company's business. Thanks are due to the Manager and staff who have so materially aided in placing the working of the enterprise on a satisfactory basis. During the past year Mr. W. F. Leese and Mr. Joaquin de Galindez have been elected directors, and their election is now brought forward for confirmation by the shareholders. Mr. H. R. Beeton and Mr. Robert Hammond retire by rotation, and offer themselves for re-election. At the meeting the shareholders will have to elect auditors for the ensuing year, and Messrs. Theobald Bros. and Miall, being eligible, offer themselves for re-election.

CAPITAL ACCOUNT.

The statement of share capital appropriated for the purposes of the House-to-House Electric Light Supply Order, 1889, shows that 100 founders' shares of £5 have been issued and paid up; 5,322 ordinary shares of £5 each out of 13,900 have been issued, and are fully paid; and 342 preference shares out of 6,000 of the same value, have been issued and are fully paid up, making the total share capital paid up £28,820, and the total remaining unissued £71,180, out of the £100,000 authorised. The loan capital authorised is £30,000, all of which has been obtained by the issue of 6 per cent. debentures, convertible into ordinary shares. The total capital received to December, 1891, was therefore £58,820.

Dr. Total Expenditure to December 31, 1891.	£	s.	d.
Lands, including law charges incidental to acquisition	56	10	6
Buildings, £8,272. 17s. 5d. (less transfer to mains, £582. 2s 1d.)	7,862	0	4
Machinery	18,721	5	1
Mains, including cost of laying the mains, £11,786 2s. 9d. (add transfer from buildings, £582. 2s. 1d.)	16,151	5	10
Transformers, motors, etc.	3,548	19	1
Meters	2,272	10	11
Electrical instruments, tools, etc.	628	7	4
Purchase of right of user of patents or patent rights and covenants with Managing Director	7,500	0	0
Cost of license, provisional order, etc.	1,537	7	7
Office furniture	97	14	10
Total expenditure	£58,376	1	6
Balance of capital account	443	18	6
	£58,820	0	0

Cr. Total Receipts to December 31, 1891.	£	s.	d.
Ordinary shares of £5 each	26,610	0	0
Founders' shares of £5 each	500	0	0
Preference shares of £5 each	1,710	0	0
Debentures	30,000	0	0
	£58,820	0	0

Dr. General Balance-sheet.	£	s.	d.	£	s.	d.
Capital—8,322 ordinary shares of £5	£41,610	0	0			
100 founders' shares of £5 each	500	0	0			
342 preference shares of £5 each	1,710	0	0			
				43,820	0	0
Temporary loan (since repaid)				3,000	0	0
300 debentures of £100 each				30,000	0	0
Sundry creditors on open accounts				7,744	15	1
Bills payable				3,538	2	5
Net revenue account—balance at credit thereof				387	15	0
				£88,490	12	6

Cr.	£	s.	d.	£	s.	d.
Capital account: Amount expended for works as per account above				58,376	1	6
Construction business development account:						
As per last balance-sheet	14,831	17	1			
Accounts for law and parliamentary charges, etc., since rendered	2,514	2	6			
				17,345	19	7
Preliminary expenses account as per last balance-sheet, £3,759. 5s. 11d., and transfer of foundation of business account, £1,709. 18s. 8d.	5,469	4	7			
Less transfer of proportion to founder, £44. 6s. 6d., and 10 per cent. of balance carried to net revenue account, £542. 9s. 9d.	586	16	3			
				4,882	8	4
Debenture issue expenses				153	13	2
Preference share issue expenses				76	17	10
Suspense renewals account				400	0	0
Stores on hand at December 31, 1890:						
Coal	168	15	0			
Oils, waste, etc.	124	2	0			
General	11	11	7			
				304	8	7
Sundry debtors for electricity supplied to December 31, 1890				3,493	6	2
Other debtors				2,313	6	1
Cash at bankers:						
Messrs. Glyn, Mills, and Co.	1,002	13	3			
Alliance Bank (Earl's Court Branch)	103	17	5			
Cash in hand	38	0	7			
				1,144	11	3
				£88,490	12	6

Dr. Revenue Account.	£	s.	d.	£	s.	d.
A.—To Generation of Electricity.						
Coals* or other fuel (including dues, carriage, unloading, storing and all expenses of placing the same on the works), oil, waste, water and engine-room stores £3,053. 18s. 7d. Less amount charged to "sundry debtors" for expenditure on experiments, running station for deputations and other considerations, £458. 1s. 9d.	2,595	16	10			
Salaries of engineers, superintendents, and officers, and wages and gratuities at generating station	1,711	8	5			
Repairs and maintenance, as follows: Buildings, engines, boilers, dynamos, exciters, transformers, motors, etc., other machinery, instruments, and tools, £827. 7s. 2d., less "suspense renewals account" transfer of expenditure on exceptional renewals, £400	427	7	2			
Cartage of ashes	93	2	0			
				4,827	14	5
B.—To Distribution of Electricity.						
Repairs and maintenance of mains of all classes				123	0	7
C.—To Rents, Rates, and Taxes.						
Rents payable	193	15	0			
Rates and taxes	200	18	3			
				394	13	3
D.—To Management Expenses.						
Directors' remuneration (special)	200	0	0			
Stationery and printing	38	3	5			
General establishment charges	232	18	5			
Auditors of Company	21	0	0			
Collector's salary	101	0	0			
				593	1	10
E.—To Law and Parliamentary Charges.						
Law expenses				24	5	7
F.—To Special Charges.						
Insurances				44	19	6
Generation and distribution of electricity expenses				6,007	15	2
Sundries.						
Subscription Electrical Association	60	0	0			
Interest and discount account	9	19	8			
				69	19	8
Balance carried to net revenue account				2,250	9	1
* Average cost of coal £1. 1s. 2d. per ton.				£8,328	3	11

Cr.	£	s.	d.	£	s.	d.
Sale of electricity per meter at 8d. per B. T. U. (less discounts				7,674	14	6
Rental of meters and other apparatus on consumers' premises				514	15	2
Transfer fees	0	12	6			
Students' instruction account	138	1	9			
				138	14	3
				£8,328	3	11

Dr. Net Revenue Account.	£.	s.	d.
Interest on debentures paid and accrued to date	1,706	0	0
Amount written off preliminary expenses account	542	9	9
Balance carried to general balance-sheet	387	15	0
	£2,636	4	9
Cr.	£	s.	d.
Balance brought from revenue account	2,250	9	1
Balance from last account	385	15	8
	£2,636	4	9

NEW COMPANIES REGISTERED.

Electric Lighting and General Development Syndicate, Limited.—Registered by C. W. and H. B. Taylor, 31, Crutchedfriars, E.C., with a capital of £700 in £10 shares. The objects for which this Company is established are sufficiently indicated by the title. There shall not be less than three Directors. The first are E. J. Rhodes and G. Morrison. Remuneration, 2 per cent. on the net profits of the Company.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for last week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £3,106.

City and South London Railway.—The receipts for the week ending 27th March were £818, against £702 for the corresponding period of last year, showing an increase of £116. The receipts for last week show a decrease of £79 as compared with those for the week ending March 20.

Anglo-American Telegraph Company.—The Directors have declared an interim dividend for the quarter ending March 31 of 12s. 6d. per cent. on the ordinary and 25s. per cent. on the preferred stock, less income tax, payable on April 30 to the stockholders registered on the books of the Company on March 31, 1892.

Spanish National Submarine Telegraph Company. — In accordance with a resolution passed at a meeting of the shareholders held on Tuesday last, a balance dividend for 1891 of 1½ per cent., of 3s. a share, is now payable. Holders of share warrants (to bearer) claiming this dividend must leave them at the Company's office, 106, Cannon-street, E.C., where the dividend will be payable; three clear days for examination.

Change of Firm.—Messrs. W. R. Wynne and A. S. Barnard inform us that since the dissolution of the firm of Barnett, Wynne, and Barnard, they have commenced business at 72, Grey-street, street, Newcastle-on-Tyne, as electrical engineers, under the style of Wynne and Barnard. Having had entire charge of the electrical department of the late firm's business, they refer to the work carried out by them in the past as a guarantee of ability. Their specialities are electric light installations for ships, collieries, private houses, etc., and the transmission of power by electricity for mining or other purposes. They also act as consulting electrical engineers, and test and report upon installations.

Henley's Telegraph Works.—At the thirteenth general meeting of W. T. Henley's Telegraph Works Company, held at the Cannon-street Hotel, on Thursday, 24th inst., the adoption of the report and accounts for the 12 months ended December 31, 1891, was moved by Mr. Sydney Gedge, M.P., seconded by Mr. Richard J. Jenkins, C.E., and carried unanimously. After writing off £6,757. 10s. from ship gear and patents, and providing £10,000 in reduction of "B" debentures, dividends at the rate of 7 per cent. per annum on the preference shares and 5 per cent., free of income tax, on the ordinary shares were declared, and a balance of £11,731. 0s. 3d. carried forward to current year's account.

Limited Liability.—It is stated that the firm of Hick, Hargreaves, and Co., Soho Iron Works and Phœnix Boiler Works, Bolton, who were established in 1832, have, for private family reasons, availed themselves of the Companies Act, and will therefore henceforth be known as Hick, Hargreaves, and Co., Limited. This alteration will not make any difference in the management, and the business will be conducted on precisely the same lines as under the old firm.—The firm of Merryweather and Sons, the well-known makers of fire-extinguishing appliances, and who have also taken up Gordon's underground conduit tramway system, have adopted a similar course. None of the capital has been offered to the public, however.

Leeds Lighting.—Subscriptions were invited this week (the lists closed on Thursday) for 10,000 ordinary shares of £5 each in the Yorkshire House-to-House Electricity Company, Limited. The capital of the Company is 20,000 ordinary shares of this value and 100 founders' shares, making a total capital of £100,000. Fifty founders' shares were offered at par to the first 50 subscribers of

£500 worth of ordinary shares. The Directors of the Company are: Grosvenor Talbot, Southfield, Burley, Leeds (chairman); George Henry Crowther, civil engineer, Huddersfield; Robert William Eddison (John Fowler and Co., Leeds, Limited), engineer, Leeds; Robert Hudson, engineer, Gildersome Foundry, near Leeds; Samuel Ingham (Illingworth, Ingham, and Co.), timber merchant, Leeds; Arthur Greenhow Lupton (Wm. Lupton and Co.), cloth manufacturer, Leeds; John Thomas Pearson, Melmerby Hall, Thirsk. The Company holds a provisional order, giving it the right of supplying electricity throughout the whole of the borough of Leeds, and was formed under the auspices of the House-to-House Electric Supply Company, which has borne all the expenses, including those attending the registration and obtaining the provisional order. The maximum price authorised to be charged is 8d. per unit. The Directors have secured the services of Messrs. Hammond and Co. as electrical engineers for the construction of the works. The registered office of the Company is 32, Park-row, Leeds, and Mr. W. T. Green is the secretary.

Sheffield Telephone Exchange and Electric Light Company. A special meeting of the shareholders of this Company was held on Wednesday at the Cutlers' Hall, Sheffield, Alderman George Franklin presiding. The object of the meeting was to adopt and confirm a provisional agreement for the sale to the National Telephone Company of the telephone exchange and telephone business hitherto carried on by the Sheffield Company. The meeting having been informed of the proposed terms of purchase, unanimously approved of the arrangement. The local company will now be at liberty to carry on its general electrical business, together with the supply of the electric light, which it has already undertaken and for which there is an increasing demand, and in connection with which a provisional order is now before Parliament, giving the Company increased powers. The terms of purchase by the National Company are such that the shareholders in the Sheffield Company will practically receive a return of the amount expended upon their telephone enterprise. It may be mentioned that the nominal capital of the local company is £100,000, with £43,000 paid up. The National Company take over the new telephone buildings at the bottom of Commercial-street, and a portion of the site, the Sheffield Company leasing the remainder of the land for electric light purposes. We understand that the National Company have accepted a stipulation that the rates in Sheffield for telephonic communication shall not be unduly increased—in other words, that the price shall not exceed £10 for the first mile, and proportionately for greater distances. Mr. William Johnson, secretary and engineer of the Sheffield Company, has been retained by the National Company as consulting engineer. The whole of the telephone staff is taken over on the terms now in existence.

PROVISIONAL PATENTS, 1892.

MARCH 21.

5511. **Means for arranging automatic shunt circuits for electrical purposes.** William Snowdon Hedley, 53, Norfolk-square, Brighton.

5515. **Improved regulating device for the carbons of electric arc lamps.** Josef Jergle, 8, Quality-court, Chancery-lane, London.

5526. **Electrical apparatus for producing flashes.** Siemens Brothers and Co., Limited, and Francis Gibson Baily, 28, Southampton-buildings, London.

5528. **Improvements in coin-freed telephone apparatus.** Harold Sims Joseph Booth, 28, Southampton-buildings, London. (Charles Herman, France.)

5546. **Improvements in or connected with the electrolytic deposition of copper or other metals.** Joseph Wilson Swan, 47, Lincoln's-inn-fields, London.

MARCH 22.

5579. **Improvements in dynamo-electric machines and motors in direct-current distribution, in leading in wires for incandescent electric lamps, and in the insulation of electric transformers.** James Swinburne, Broom Hall Works, Teddington.

5618. **Improvements in alternate-current transformers.** Thomas Boyden, Florence Villa, Old Dover-road, Blackheath, London.

5634. **Improvements in electrically-controlled elevators and switch mechanism for use therewith.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (Nelson Hiss, United States.) (Complete specification.)

5645. **Improvements in or connected with electric batteries.** Lazarus Pyke and Edward Stephen Harris, 433, Strand, London.

5652. **Improvements in and relating to conduits for electric railway conductors.** Henry Harris Lake, 45, Southampton-buildings, London. (The Thomson-Houston International Electric Company, United States.) (Complete specification.)

5654. **Improvements in dynamo-electric machines.** Antoine Charles Reignier, 23, Southampton-buildings, London. (Complete specification.)

5655. **An improved electric safety-lamp.** John Price Rees, 11, Southampton-buildings, London.

MARCH 23.

5712. **Improvements in and connected with diaphragms of telephones.** George Lee Anders and Walter Köttgen, 55, Chancery-lane, London.

5732. **Improvements in or connected with electric light fittings.** James Aram Lea, James Francis Lea, and Arthur Henry Lea, 4, South-street, Finsbury, London.

5735. **Improvements in connections for electric lighting.** Hugo Hirst, 11, Furnival-street, Holborn, London.

5748 **Improvements in electric meters.** George Shann, 3, Park-row, Albert-gate, London.

5750. **Switch for electrical circuits.** Edward Hibberd Johnson, 23, Southampton-buildings, London. (Date applied for under Patents Act, 1883, Sec. 103, 25th August, 1891, being date of application in United States.)

MARCH 24.

5812. **Improvements in arc electric lamps.** Henry Robert Low, 28, Southampton-buildings, London.

5814. **Improvements in microphones and in apparatus connected therewith.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London.

MARCH 25.

5828. **An improved method of rapid tanning with the aid of electricity.** Charles Krauss Falkenstein and Konrad Krauss Falkenstein, Homeleigh, Lanercost-road, Tulse Hill, London.

5850. **Improvements in or connected with telephone fittings.** Ridley James Urquhart, 57, Barton-arcade, Manchester.

5891. **Improvements in or connected with holders or supports for the ear tubes of telephones.** William Frederick Matthews, 27, Southampton-buildings, Chancery-lane, London.

5899. **Improvements in apparatus for adjusting and regulating the carbons of electric arc lamps.** Emile Francois Marie Loevenbruck, 35, Southampton-buildings, London

MARCH 26.

5931. **Improvements in the construction of multipolar dynamo-electric machines.** Wilfrid L. Spence, The Elms, Seymour-grove, Manchester.

5933. **New accumulator battery for telegraph offices for military telegraphs in the field, also for lighting trams, omnibuses, carriages.** Gaspare Sacco, 14, Leicester-place, London.

5954. **Improvements relating to voltmeters.** Frederick Brown, 37, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1880.

678. **Electric lamps.** Edison. (Fourth edition.)

1890.

232. **Electric motors, etc.** Hopkinson and others. (Second edition.)

1891.

2040. **Secondary batteries.** Müller.
2471. **Electrical batteries** Bush and Doubleday.
4740. **Electrical signalling for railways.** Attree.
6660. **Distributing electrical energy.** De Ferranti.
7075. **Electric lampholders, etc.** Royce.
7372. **Actuating hammering, etc., machinery by electricity.** Bolton and Mountain.
7430. **Driving dynamo-electric machines.** Heaviside and others.
7433. **Testing electric lighting conductors, etc.** Salomons.
7518. **Telegraph instrument.** Bullock and Brown.
7531. **Tools for electric linemen.** Cuthbert.
7697. **Storage batteries.** Elieson.
7728. **Electric lampposts.** Lea.
8048. **Dynamo-electric generators.** Kennedy.
8845. **Galvanic batteries.** Haddan. (Cabanyes.)
16958. **Electric lighting, etc. conductors.** Mavor and others.
19968. **Electric motors etc.** Burt.

1892.

2016. **Conduits for electrical cables, etc.** Price.
2026. **Electric telephones.** Lake (Grissinger and another.)
2290. **Electric riveting.** Ries.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3⅜
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5
Metropolitan Electric Supply	—	9
London Electric Supply	5	1¼
Swan United	3½	4½
St. James'	—	8¾
National Telephone	5	4¼
Electric Construction	10	6¼
Westminster Electric	—	6¾
Liverpool Electric Supply	5	5¼
	3	3

NOTES.

Adrianopolis.—A new tramway is to be established by the municipality at Adrianopolis.

Deputations.—A party of railway and other engineers visited the Crystal Palace on Thursday.

World's Fair.—The electricity and machinery buildings are rapidly advancing towards completion.

Clearing-house. — We understand that Mr. Geere Howard has received the contract for the lighting of the Clearing-house.

Mansfield.—The Mansfield Town Council have had a very animated discussion with reference to the poor lighting of the public streets by gas.

Royal Institution.—Before the Royal Institution to-night (Friday), at 9 o'clock, Prof. W. E. Ayrton, F.R.S., will read a paper on "Electric Meters, Motors, and Money Matters."

Manchester Ship Canal.—On and after June 1 the Ship Canal Passenger Steamer Syndicate will have a fleet of electric launches to let for private parties on the Manchester Ship Canal.

Flying Machines.—The French Government have a dirigible balloon, "La France," the driving power for the propeller being obtained from a motor worked by Renard's primary battery.

Toynbee Hall.—The next of the science conferences will be held on Wednesday, April 13, when a paper will be read on "Electrical Installations," by Mr. Reginald J. Jones, M.I.E.E., A.M.I.C.E.

Electric Traction.—An interesting series of articles on various systems of electric traction have been appearing in the *Glasgow Herald*, and is being reprinted in book form by the General Electric Power and Traction Company.

General Electric Power and Traction Company. We understand that Mr. Robert Macpherson has resigned his position as general manager of the company. This necessarily implies a reorganisation of directorate and staff.

Coast Communication.—The Balloon Society have awarded the Merrett silver medal to Captain Benest, C.E., M.I.E.E., late of the "Retriever" telegraph ship, for his distinguished services and his paper on "Electric and Telephonic Coast Communication."

Atlantic Cables.—The United States' Foreign Commerce Committee of the House of Representatives has ordered a favourable report on the resolution to allow the French Paris-New York Telegraph Company to lay cables along the cost of North Carolina and Virginia.

Manchester Cables. — The International Okonite Company, Limited, of Newton Heath, Manchester, and of Queen Victoria-street, London, have secured the contract from the Manchester Gas Committee for the electric mains for the Manchester central electric lighting station.

Tempered Copper.—The largest copper foundry in the world is that of the Eureka Tempered Copper Company, of North East, Pennsylvania. The tempered copper discovered by Mr. Almer Thomas is largely used for dynamo commutators and other parts of electrical apparatus.

Electrical Instruments. — Messrs. Whittaker will issue, immediately, a fifth edition of Mr. Bottone's work on electrical instrument making, revised, with additional chapters containing a few simple instructions for making a small arc lamp, an incandescent lamp, a current reverser, and so forth.

Telegraph Posts.—An application was granted at the meeting of the Highways Committee of the Norfolk County Council for permission to erect posts on the road to Yaxham, the county surveyor explaining, in answer to questions, that there was no royalty on telegraph poles, but there was on telephone poles.

Edinburgh.—At a meeting of the sub-committee of the Edinburgh Town Council last week, the city law agent reported that it was quite within the right of the Corporation to delegate their powers to a company. A report was submitted at the same time from the deputation who recently visited Glasgow on the subject.

Australia Cables.—A Reuter's telegram from Brisbane says: "The French Government will pay £3,000 towards the cost of laying the cable to New Caledonia, and New South Wales and Queensland £2,000 each. The cable will be laid in 18 months. The Queensland Government is to receive one-seventh of the charges."

Rubber Trust.—It is stated that a gigantic rubber trust has been formed in New York, with a capital of 50,000,000dols., and the extent of its operations and prospects of success may be estimated from the fact that it embraces every manufacturing and wholesale concern in the United States with one solitary exception.

Florence.—The gas company of Florence is intending to establish a central electric lighting station, and has put a certain sum in reserve for this purpose. The municipality has, it appears, already entered into competition with its gas company, and the law has been invoked, the decision being against the town authorities, both in the first instance and on appeal.

Electric Mail Service.—A hundred thousand dollars has been voted by the United States Congress for improved express mail service between New York and Brooklyn. The plans of Mr. A. Bryson, jun., of New York, are being considered for electric motor cars 6ft. long and about a foot square, driven electrically through a tube at the speed of 100 miles an hour.

Huddersfield Town Hall.—As will be seen from their advertisement, the Corporation of Huddersfield invite tenders for the electric wiring and electric light fittings for the Town Hall and Borough Offices. Specification and plans may be obtained from Mr. A. B. Mountain, borough electrical engineer, 1, Peel-street, to whom tenders must be addressed by Thursday, April 28.

Nicaragua.—A concession has been granted by the Nicaraguan Government to Dr. Louis Cruz for the establishment of a complete telegraphic service in Nicaragua. All the material will be admitted duty free, and no similar privilege will be granted during the continuance of the concession. In return the Government are to be furnished with 25 instruments and all connections free of expense.

Compound-Winding Patent.—As will be seen from the full report given elsewhere of the judgment in the Scotch Courts in the case of the Anglo-American Brush Electric Light Corporation *v.* King, Brown, and Co., that decision on appeal has been made against the validity of the Brush patent, and therefore another extensive patent—that of the compound winding of dynamos—is thrown open.

Multiphase Currents and the Telephone.—The effect of the multiphase current on the telephone is much less than that of the simple alternating current, according to the account of experiments at Offenbach, published in the *Neue Tageblatt*. Conversations could be carried on when the telephone line was strung for a distance of five miles within 3ft. of the wires carrying the rotary current.

Fire Alarms for Chelmsford.—Chelmsford Town Council have adopted the recommendation of the Fire Brigade Committee that tenders be obtained for three alternative schemes for giving alarms of fire. The first provided for electric bells, the second for a telephone (from the police station to the pumping station), and the third for four strong fire alarms in various positions in the town.

Incandescent Lamps. — As will be seen by their advertisement, the Edison and Swan Company announce that a discount of 10 per cent., with additional cash discount of 2½ per cent., will be allowed to the trade on all incandescent lamps. In order to prevent underselling by anyone of the trade, this discount will be allowed only on the express condition that they do not allow more than 5 per cent. discount to private customers

Miners' Lamps.—M. Donato Tommasi has been giving his attention to safety-lamps for miners, with special reference to security in explosive mixtures. Contact of the terminals with the filament is made by means of an expanding bulb inside the outer envelope. This outer globe is pumped full of air and stopped by a tap. The lamp is put out by turning the tap, or by breaking either the inner or outer bulbs, by reason of the expansion of the flexible contact.

Cheap Trips to the Crystal Palace.—The season of cheap trips, including admission, to the Electrical Exhibition at the Crystal Palace has commenced, and is likely to prove very successful. That by which a number of inhabitants of Canterbury and other East Kent towns were enabled to visit the wonders of electricity last week seemed to be thoroughly enjoyed. Several members of the Dover Corporation took part in the excursion, and the Mayor of Canterbury, with about 100 citizens, also formed an important deputation.

Dundee.—A special meeting of the Electric Lighting Committee of the Gas Commission was held last week to consider plans of the buildings connected with the proposed electric light installation. Mr. Urquhart, of Messrs. Urquhart and Small, engineers, Westminster, the Board's consulting engineers, attended, and went over the plans with the committee. Several alterations regarding matters of detail were suggested, and it was ultimately agreed to submit the plans to Prof. Kennedy, who will report upon them to the Board.

University Boat Race.—Electric boats will be well in evidence at the Oxford and Cambridge Boat Race on Saturday. The General Electric Traction Company will have several of their larger boats filled with visitors invited by Lord Albemarle and the directors. Mr. W. S. Sargeant will also have a barge near the winning-post at Mortlake, as well as some launches, and wishes it to be understood that any electrical engineer (and lady) who wishes to attend would be welcomed. A line to his address at Chiswick would be advisable. If the weather lasts, this race should be a great success.

Wimshurst Machine.—In the Wimshurst machine as at present constructed the polarity is left to chance, and the experimenter cannot tell in advance at which conductor it will be positive. Herr J. C. Pürthner, of Vienna, finds that it is sufficient to rub one of the brushes strongly on the ebonite plate for positive electricity to appear on the same pole of the machine. The pressure, however, wears away the tinfoil at this place, and to obviate this a third brush is attached to the cross-arm, and the pressure of this on the ebonite can be increased without inconvenience until the polarity of the conductor remains the same.

Burnley.—The Gas Committee of the Burnley Corporation met on Thursday last week, when, at the suggestion of the Electric Lighting Sub-Committee, it was decided to recommend the Council to authorise the committee to obtain tenders for buildings, boilers, engines, and the necessary plant for the proposed electric lighting installation. The sub-committee do not intend to proceed with the work until the necessary authority for the borrowing of the money has been obtained from the Local Government Board, and this will in all probability take some little time. In the meantime detailed plans and specifications will be prepared.

Journal.—The new number of the *Journal* of the Institution of Electrical Engineers (No. 96) has been issued, containing Prof. Ayrton's presidential address on "Electrotechnics," together with photographs and plans of the technical schools referred to in the address. These include the Royal Technical High School, Charlottenburg, Berlin; the Montefiore Electrotechnical Institution at Liége; the Massachusetts Institute of Technology, Boston; Franklin Hall, Cornell Univerity, Ithaca; and the Polytechnic, Zurich. The full list of officers and members of the Institution, and the index to vol. xx., are also issued by Messrs. Spon.

Lane Fox Patents.—A notice has been advertised that a petition to the Privy Council will be presented for the extension of the regulating patent No. 3,988, of 1878, granted to St. George Lane Fox, for a further term, and that the 9th of May next, or on such subsequent day as the Judicial Committee of her Majesty's Privy Council shall appoint for that purpose, application will be made to that committee that a time may be fixed for the hearing of the matter of the petition; and any person desirous of being heard in opposition to the petition must enter a caveat to that effect in the Privy Council Office on or before the said 9th day of May next. The notice is issued by Messrs. Vandercom and Co., 23, Bush-lane, E.C., solicitors for the petitioners.

Hull.—At a meeting of the Hull Corporation Electric Lighting Committee held last week, it was unanimously decided that, in consequence of the necessity for laying so many more yards of main by reason of the change of site, the committee recommends that the estimate for the installation be increased by a further sum of £3,000. Tenders for the alterations and additions to the electric light station were opened, and that of Mr. Grasby, Cumberland-street, for £2,864, was accepted. Mr. Bingley, the architect, had estimated that the cost would not exceed £2,300, and it was suggested that the Corporation should undertake the work themselves, but this fell through on it being pointed out that the borough engineer's department was full up with work, and that it was probable that considerable cost would have to be incurred in providing new and special plant for carrying on the work.

Rothschild Electric Carriage.—An electric carriage has recently been constructed, the mechanical details of which were worked out at the Rothschild works, at St. Ouen, near Paris. The motor was supplied by the Société pour la Transmission de la Force; it is of 3 h.p., running at 2,000 revolutions with 100 volts. Current is supplied by 48 accumulators, supplied by the Société pour le Travail Electrique des Metaux, weighing 8 kg. (17·6lb.), each with a capacity of 10 amperes per kilogramme of useful plate. Three different groupings can be given: four sets of 12 cells, giving 25 volts, corresponding to a speed of 3¾ kilometres (2⅓ miles) an hour. Half-speed is obtained by two sets of 12 cells, giving a speed of 7½ kilometres (say 4½ miles); and with all cells in series a speed of 16·8 kilometres (say 10½ miles) an hour can be obtained. The carriage will run 35 to 40 kilometres (say 23 to 25 miles) with one charge.

Subways Bill.—The Select Committee continued last Friday the examination and discussion of the clauses of the London County Council (Subways) Bill. The clauses having been settled with the gas companies, an amendment was moved by the County Council to make the Bill take the form of a general Act, which could be incorporated in all future Acts relating to subways. The committee, however, regarding the provisions of the Bill as experimental, declined to insert the amendment, and in its place inserted a clause that the provisions of this Bill should not apply to any further subways unless expressly re-enacted. The effect of this decision is that the Bill now only applies to the existing nine subways already constructed in London. Other clauses having been considered, the Bill, which now contains but very little of the originally deposited Bill, was ordered to be reported to the House for third reading.

Lynbridge.—A letter was read from Mr. Benn at the last meeting of the Lynmouth Local Board, stating that he was prepared to light Lynbridge with electric light, provided the Board would enter into a 14 years' contract. The Lighting Committee advised its acceptance; also Mr. J. Crocombe's guarantee to provide £5 per annum towards the expenses of an arc electric light on the Rhine Tower at Lynmouth. Mr. Beck was of opinion that a 14 years' term was too long, as there was a prospect of obtaining electric light at a much cheaper rate, as the different patents and royalties would soon be run out; he therefore considered that a seven years' term would be sufficient. It was explained that the expenses of laying a cable to Lynbridge would be considerable, and that Mr. Benn would not be willing to lay on the light without a contract for the 14 years' supply. The Lighting Committee's report was adopted.

London County Council.—The Highways Committee of the London County Council reported last week stating they had already suggested to the Board of Trade certain amendments in the model order which the Board proposed to adopt for use in cases where the local authorities apply for powers under the Electric Lighting Acts. Four such applications have been made this year; and the Board of Trade has forwarded, for the Council's observations, two of the proposed orders—namely, those applied for by the Vestry of Hampstead and the Whitechapel District Board—in the form in which the Board proposes to issue them, nearly all the amendments suggested on behalf of the Council in the model form of order having been adopted. The committee have carefully examined these orders, which appear to be satisfactory, and recommend that the Board of Trade be informed that the Council approves of the form in which the Board proposes to issue the said orders.

Lead-Covered Conductors.—The substitution of lead instead of zinc for coating or galvanising conductors is advocated in an article in *L'Electricien.* Zinc has certain disadvantages—tendency to form an alloy, high melting temperature, tendency to flake off. Lead seems to be preferable for certain reasons, and its application is similar to that of zinc. The objects are cleaned electrically, and immersed in an aqueous solution containing 10 per cent. of hydrochloric acid and 1 per cent. of hydrofluoric acid, heated to 50deg. C. in a vessel coated with lead. They are connected to one pole of a dynamo as anode, the lead coating constituting the other pole. After this preparation they are dipped into lime-water of the same temperature, and then into an alloy of equal parts of zinc and tin in hydrochloric acid, which greatly favours the adherence of the melted lead, into which they are then dipped. The process is economical and is not confined in its advantage to iron or steel articles, but may be used for chemical and electrolytic vessels. The iron or steel wires serving as protection in armoured cables, it is suggested, might be advantageously treated by this method in preference to the ordinary galvanising process.

Self-Discharge of Accumulators.—Dr. Krügel, of Berlin, gives an account in the *Elektrotechnische Zeitschrift* of the result of some interesting and important observations upon the discharge of the negative plates of secondary cells on open circuit. The observations were carried out upon Tudor cells. In an installation it had been remarked that the capacity of a battery was much less than that guaranteed, and that the battery left by itself became discharged in a few hours. A careful examination showed that the negative plates only were discharged, the metallic lead becoming oxidised with much disengagement of hydrogen. Other negative plates were put in their place after a strong charge, and the battery now acted well. Numerous tests and analyses showed that the cause was due to the presence of foreign metals dissolved in the electrolyte, which were deposited during charge on the negative plates, where they form couples with the reduced lead. In particular, on the acids giving this effect were found copper, arsenic, antimony, molybdenium, and platinum, the latter having a decided effect even if only in quantities of one-millionth. The manufacturers now only use the acid after having precipitated the metals by sulphhydric acid.

Hull Tramways.—Since the collapse some time ago of the negotiations between the Hull Corporation and a syndicate of gentlemen for the leasing to the latter of the Hull street tramway system, which the Corporation are arranging to take over from the existing company or companies, negotiations have been opened up with other gentlemen with a view to working the system on a lease, and a sub-committee of the Corporation have this week been in London, says the local paper, engaged in completing the preliminary agreement. This, it is understood, has been done, though at present everything is dependent upon whether the Corporation are willing to agree to the arrangement, which is only provisional. The terms of this have not yet been made public, but it is stated that they provide for the taking over of the whole of the tram lines of the town, the cars on a portion of which are now drawn by steam, the making of double lines in lieu of the present single line with sidings, and the leasing of the whole to a syndicate who will supply a four-minute service of electric cars. Such an arrangement, if the terms prove acceptable to the Corporation, will be regarded with satisfaction by the townspeople.

Increasing Revenue.—How electric companies can increase revenue without increasing their charges is the problem investigated by Mr. J. H. Babcock in the New York *Electrical Engineer.* By using the exhaust steam for heating houses and buildings, says Mr. Babcock, and quotes an example he has in his mind's eye of an electric plant in a town of less than 20,000 inhabitants in which the exhaust steam is thus used. The power station contains three boilers of 100 h.p. each, and one of 150 h.p. The company has itself constructed four and a half miles of electric railway, which runs 18 hours out of the 24. It also does lighting, for which plant is in use 12 to 14 hours a day, so that some power is required throughout the whole day and night. Its exhaust steam the company circulates in 2½ miles of underground steam-pipes of 10in., 8in., 6in., 5in., and 4in. diameter. In these a pressure of 12·15lb. of steam is carried; this produces a back pressure in the engines, and the boiler pressure is increased to this extent. The company has now 138 customers, paying an average of 100dols. "a season." Meters are used. The income from this department is sufficient to pay 6 per cent. on

150,000dols., and the outlay for pipes was only one-quarter this amount.

Utilisation of Water Power in France. — A scheme on a large scale for the utilisation of water power by electricity has been recently elaborated by the French Conseil d'Etat. A navigable canal is to be established between Jous and Lyons with water power from the Rhone, and the force of the waterfall which will be thus created will be used to distribute power by electricity. The work is to be carried out by a private combination of capitalists, amongst whom are MM. Chabrières, Arlès, Demachy, Pila, de Reinach, and others, who will have the right during the concession to the sale of power and accessory products. In return the prefect will have control over the work and exploitation. No absolute monopoly, subvention, or guarantee is given. A limited company is to be formed six months after the passing of the project, which will spend 12 million francs on actual work. The charges by the departments through which the wires are led are not to exceed 5c. (½d.) per metre for two conductors, or 10c. (1d.) per metre above this. The Lyonnais district is rich in natural forces and in possibilities for their utilisation, and the scheme is understood to have the sanction of engineering and electrical experts. It does not appear to be decided whether alternating, rotary, or direct currents are to be used.

Liverpool.—Before the Liverpool City Council on Wednesday the minutes of the Watch Committee were discussed. These contained a resolution that having considered the question of using the electric light in lieu of the present mode of lighting the city, the committee were of opinion that, having regard to the conditions of rapid development to which the system of electric light was now subject, it was not at present advisable to adopt the system in the city. Mr. Purcell congratulated the city engineer upon the concise and interesting report he had prepared on this subject. He should like to know why the engineer's recommendation to try the experiment in a certain area had not been adopted by the committee. Mr. Duncan replied that the average cost of lamps in the city was £3. 3s. per lamp, but in the district marked out by the engineer the cost was as much as £5. 8s. per lamp. Considering that the cost would have to be defrayed by the whole of the ratepayers, and also remembering that this particular district was at the present time exceptionally well lighted, the committee did not see their way to carry out the engineer's suggestion. The committee had no desire to shelve the question. Electrical developments were going on every day, and as a large scheme was being tested in London, the committee thought it wise to wait until they ascertained by that experiment how much light was obtained, and at what additional cost. Mr. Brownhill thought the Council-chamber should be lighted by electricity; the Mayor remarking that he had no doubt the chairman of the Finance Committee would take that into consideration. The recommendation was confirmed.

Worcester.—A meeting of the Worcester City Council was held on Tuesday to consider the establishment of an electric lighting central station. Mr. Alderman Hill moved, "That, subject to obtaining the sanction of the Local Government Board to the requisite loan, this Council, is in favour of accepting the tender of the Brush Electrical Company for supplying electric light for the city, but delays the actual acceptance of the tender pending the receipt of a report from the Watch Committee as to the portion of the tender which should be accepted, and especially as to (1) whether provision should be made for steam power only, or steam and water power combined; and (2) should provision be made for street lighting." Mr. G. H. Williamson seconded. Mr. Millington said that the Council would at present be voting in the dark, and moved that the members be supplied with copies of the tenders of the Brush and Storage systems. Mr. Chaplin seconded. After a long discussion, Mr. Millington's amendment was carried by 21 votes to 15. The following is the list of figures and companies tendering—the abstract of the report on these we gave last week. The amounts are total cost of plant and mains, but do not include buildings:

Electric Construction Company	£39,165
Siemens Bros. and Co.	33,850
Westinghouse	32,288
Paterson and Cooper	32,000
Woodhouse and Rawson	29,119
Crompton and Co.	29,117
Hammond and Co. and J. Fowler and Co. (jointly)	24,824
Laing, Wharton, and Down Syndicate	22,875
Electrical Power Storage Company	21,249
British Electric Installation Contractors	21,169
Brush Electrical Engineering Company	21,005

Messrs. Ferranti, we believe, only tendered on the basis of 9,000 instead of 12,000 8-c.p. lamps.

Leeds Electric Tramways.—The whole question of electric tramways must shortly be considered by the Leeds Corporation. It seems evident that the Leeds Tramways Company have decided to allow the lease of the lines now under its management to continue until the expiration in August next. The Wellington section of the ordinary tramway is being relaid, and the Headingley section, which was recently condemned by Major-General Hutchinson, has been put into a more satisfactory condition. Notwithstanding the delay in the transference of the company's undertaking to the Corporation, the Council will before long have come to some arrangement as to the future working of the tramways, and in the consideration of this matter one of the most important factors will doubtless be the question as to whether the electric system shall be adopted on any of those lines now worked by horse or steam power. The electric tramways are already being extended by the continuation of the line from Green-road, along Beckett-street, and down to York-street to the junction of the latter thoroughfare with Kirkgate, near the Covered Market. The additional section has been temporarily leased to Mr. Graff Baker, the lessee of the Roundhay Park electric tramway. The work of laying down the roadway and putting up the poles and overhead wires is proceeding satisfactorily, the rails have been ordered, and it is expected that the extension will be completed by Whitsuntide. When that is done the electric tramway will form a direct connection between one of the busiest parts of the town and Roundhay Park, and will not only be serviceable to the numerous population living along the route, but to the townspeople going to and from the park, who would otherwise go by 'bus, or be obliged to change cars at Sheepscar. There has been some talk of extending the electric tramway at the Roundhay Park terminus by making a circular route along one of the new roads, but nothing definite has yet been settled in this direction.

Blackpool.—The project of the Blackpool Corporation for the extension of the electric lighting is likely to have an immediate outcome. A comprehensive report of the investigations of the Electric Lighting Committee is to be submitted at the next Council meeting, in which the committee not only recommend the adoption of a complete installation for the town, but submit a definite system to proceed upon, a certain price to be charged, and full details for management and control of the works.—A meeting was held last week, at which Mr. Councillor Pearson addressed the Blackpool Tradesmen's Association. The chairman (Mr. Councillor Heap) stated that the monopoly of the

Corporation would expire this year, and that unless they resolved to establish a complete installation private companies might step in. Mr. Councillor Pearson then explained the position. Three or four years ago a resolution to obtain a provisional order was attempted, but defeated. Eventually an Electric Lighting Committee was formed, and this committee had collected ample information. A circular letter would shortly be issued by the town clerk to tradesmen and ratepayers, enquiring how many lamps would be required. The price had not yet been fixed, but it was not thought that it would be above 7d. per Board of Trade unit. The limit was 8d., and they would supply at 6d. if found possible. The average cost of wiring would be £1 per lamp, and at 8d. the outside limit, the charge would for current amount to less than ½d. per hour. With regard to arc lamps, he considered these suitable for shops and advertising purposes, and the committee had recently seen a very pretty lamp called the Midget, which came to about £5 per lamp first cost, and about £3 to £5 a year to burn. The speaker stated that the committee intended to extend the lighting of the Promenade and some of the principal thoroughfares. The chairman thought the winter gardens and the theatres, circuses and large business places, would have the light at once. He estimated the cost of plant between £15,000 and £30,000, but did not think it would be less than £20,000. A resolution was carried that the meeting considered it the duty of the Corporation to install the light at Blackpool for public and private purposes, to prevent outside companies from obtaining powers.

Dublin-Belfast Telephone.—A project of great importance to Ireland was inaugurated on Tuesday at the Belfast Chamber of Commerce, when the National Telephone Company opened telephonic communication between Dublin and Belfast, which are upwards of 100 miles apart. A number of leading gentlemen witnessed the inaugural experiments, including the Mayor of Belfast, the President of the Belfast Chamber of Commerce, the Chairman of the Harbour Commissioners, and the Postmaster. The Mayor having been called to the chair, Alderman Connor, as chairman of the local board of the telephone company, made a short statement relative to the introduction of the telephone into Ireland and its establishment in Belfast. The first efficient instrument for exchange purposes was exhibited in Belfast in that Chamber just 12 years ago, between the Chamber and the warehouse of Messrs. Ewart in Bedford-street. In April of that year an exchange was opened in Belfast, and about 50 subscribers were provided with telephonic communication. Before many months arrangements had to be made to increase the accommodation. The old switchboards were abandoned, and the multiple board of the Western Electrical Company of Chicago was introduced. Lines were made to Larne, Lurgan, Portadown, and elsewhere, but the demands continued to grow, and new premises had to be taken in High-street, and all the latest improvements placed there. In old days, the number of calls a day would be 300 or 400; now they were about 7,500, or about 10 calls for each subscriber. Most of these calls were made during three or four hours of the day. The line which had just been completed to Dublin was on the most approved principle, known as the metallic loop. The Telephone Company of Ireland had made special lines to Dundalk, Drogheda, and Castlebellingham. It was the intention of the company, after that line had been opened, to afford the public an opportunity for one week of communication with Dublin free of charge, and so give them a more intimate idea of the possibilities which might yet accrue from a line of telephone. Congratulatory messages then passed between the Lord Mayor of Dublin and the Mayor of Belfast, arrangements having been made so that many of the visitors present could also hear the messages. The speaking was very distinct, and the whole ceremony exceedingly interesting.

Non-Arcing Metals.—An interesting paper, apparently opening an investigation into a somewhat novel field, was read by Mr. Alexander J. Wurts before the American Institute of Electrical Engineers, on "Lightning Arresters and the Discovery of Non-Arcing Metals." Mr. Wurts wished to obtain a satisfactory lightning arrester, and the idea (emanating from Mr. Paul Winsor) was that if an arc was established in the neck of a bottle the rising of the heated air would break it. The advantage of a self-breaking arc would be for adaptation to lightning arresters, for in these a discharge sometimes establishes an arc over which the main circuit current is diverted. The first idea was carried out in practical form, and a 1,000-volt 4,000-light machine was short-circuited through such an arrester 400 times without deterioration. For an arc-light circuit he adopted the idea of a pivoted carbon contact passing into a chamber in which, if an arc were established, the air expanded and blew the contact over into the adjacent chamber, where it nearly touched another contact, thus breaking the arc, but resetting the arrester. These acted on a non-inductive circuit. He next tried some experiments with a belt giving off frictional electricity. Stretching a wire parallel to the belt, beautiful purple streamers were given as an aurora to the wire. Sparks issued from the wire if insulated, but not if one end were grounded. Then a second wire was stretched parallel to the first and grounded; thereupon no action was experienced in the first. Soon after he learned that an overhead grounded wire had been used to advantage, and was surprised that it was not more in general use. He next tried some experiments that are certainly novel, which we will briefly describe, necessarily much condensed. An interrupter was made of saw-edged carbon with $\frac{1}{16}$in. air gap on a 1,000-volt circuit, combined with instantaneous break and remake contrivance. The air gap was bridged by tinfoil, and the switch turned. An arc formed, the device acted, and the arc stopped, but immediately went on again, due to the rush of current across air gap to the white-heated carbons. The discharger was now made of three solid brass rods, having air gap of $\frac{1}{16}$in. The result was a success, the spark being insignificant. But with large bars, 2½in. diameter, the bars of metal were melted like wax. He investigated this interesting result—the smaller bars again gave an arc no bigger than a pea. To make a long story short, Mr. Wurts found the difference was not in size nor physical structure, but their composition—bars containing tin and copper acted badly, bars containing zinc and copper broke the arc at once. Dischargers were made of hard steel, hard-drawn copper, aluminium bronze, and aluminium—all of which failed. The next tested was zinc, which was most successful. Tin and nickel failed—tin making a splendid fiery display. Antimony worked perfectly. The theory advanced is that zinc and antimony chokes the air gap with vapours of high resistance, and so stops the arc. The chemical properties of zinc and antimony were compared with the others tested, and it was seen that of these latter none were in the zinc group according to Mendelejeff's grouping. The other metals in the zinc group are cadmium, mercury, and magnesium. Cadmium was found non-arcing. Manganese also, curiously enough, is non-arcing at low E.M.F. (100 volts), but took fire, as expected, at 250. Mercury, in the form of a copper amalgam, was the most successful of all. Currents of 1,000 volts were used in all tests except in that of magnesium. A practical non-arcing discharger is made by Mr. Wurts on th

THE CRYSTAL PALACE EXHIBITION.

DIRECT-CURRENT DYNAMOS.—III.

BY R. W. WEEKES, WHIT.SCH.

Construction of Commutators.—The insulation of the commutator segments has been much improved of late years. The first makers of dynamos used asbestos sheet or vulcanised fibre to insulate the commutator parts, but these were found to have neither the mechanical or electrical properties required.

When the dynamo was placed in a situation exposed to damp air, the asbestos absorbed the moisture, thus ruining the insulation. The mechanical failing was due to the soft character of the material. It always wore away more quickly than the metal, and so left grooves in which dirt and copper dust accumulated. This failing made it difficult to keep a good surface on the commutator. A file could not be used without filling up the grooves, and if the commutator was turned up in the lathe the edges of the strips were almost sure to burr over and short-circuit.

It may be that these difficulties were increased by the sparking which occurred in these early machines, but I think that asbestos will never come into favour again for this purpose. Mica is now always used, and it successfully overcomes the above-mentioned faults. It also has a special value as a lubricator, and helps to maintain that burnished surface on the commutator which is the pride of dynamo attendants.

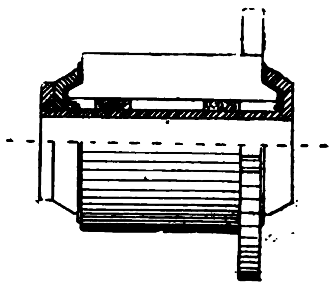


Fig. 19.

The sparking at the brushes has been overcome by improvements in the design, chiefly by the use of very strong magnetic fields, and correspondingly few turns of armature conductor. Also the number of commutator segments has been increased, and thus the self-induction of the part of the conductor short-circuited while passing under the brush has been diminished very much The best material to use for the segments is still a matter undecided.

At first cast brass was used, then rolled copper of the

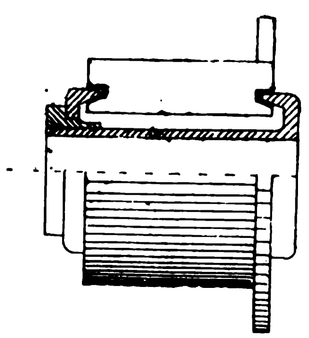


Fig. 20.

desired section replaced this, and now there is a tendency to revert to castings, the metal used being copper, or as nearly pure copper as it is possible to cast. The casting has the advantage of enabling the lug to be made in one piece with the segment, and the makers who use them say that uniform wear can be obtained if the selection of the metal is carefully attended to. The drawn copper strip has the recommendation of having passed a long trial successfully, and will not be displaced easily. The cast-brass commutator is still used by one or two makers.

The connection of the conductor to the commutator is effected by soldering by all the English makers, but the screw connection is still used in the dynamos imported by Messrs. Laing, Wharton, and Down.

Methods of Holding the Segments.—The first essential is that the segments should be gripped so that the strain tends to force them together more closely. This is generally done, Figs. 19 and 20, by two conical surfaces, one at either end of the commutator. This by itself is not

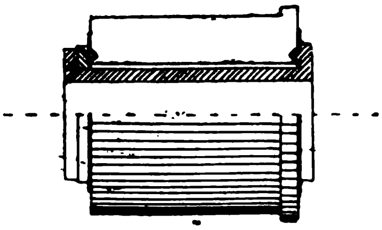


Fig. 21

sufficient to prevent displacement, as a blow will drive one segment in below the others. Many firms use this method of holding the parts, but their arrangements to prevent this latter fault differ slightly.

Messrs. J. H. Holmes and Co. have adopted a hard wood ring turned to fit the inside of the commutator, as shown in Fig. 19. This ring need not be a fit on the commutator centre. Messrs. Siemens Bros. and Co. fit the segment directly on to the centre, Fig. 22, and insulate with mica. In this case the mica is inserted in slots in the commutator centre, and small pieces are placed under each segment. Many other firms adopt somewhat the same arrange-

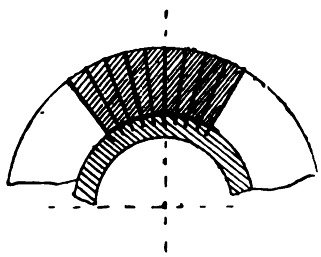


Fig. 22.

ments of supporting the segments on the centre, except as regards this latter detail. The cones are usually insulated with fibre, but asbestos saturated with varnish, after having been pressed into shape, answers well. Mica is sometimes used, but it is difficult to get uniform insulation by sticking pieces together round the cone.

Another method of preventing the displacement of a single strip, is that used by Messrs. Johnson and Phillips, Fig. 20. The segments are keyed together by the ring of insulation, shown black in the sketch.

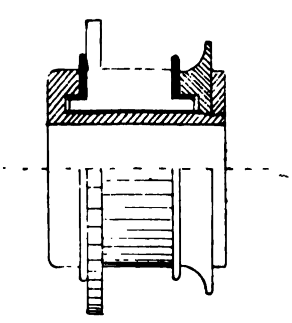


Fig. 23.

This is usually fibre or ebonite, and while making an effective tie, it does not prevent the cones binding the whole commutator together.

The double cone, Fig. 21, is still used, but it has only the advantage of complying with the last requirement. The centre requires most accurate fitting, and then does not put any inward pressure on the segments to bind them together. The Electric Construction Corporation have dispensed with cones, and use large flat surfaces, Fig. 23. The ends are insulated with fibre, and the centre is made a driving fit over the projecting pieces, so as to bind them together.

Brushes.—The gauze brushes have now come generally into use, and the great majority of the machines in the Exhibition are fitted with them. The material used is either brass or copper gauze, and some makers claim that the brass brush runs cooler on copper commutators. Carbon brushes are not shown in use in any of the larger dynamos, and I hear that it is difficult to get them to run cool while taking off the same current as the copper brushes. This does not, however, detract from their usefulness in tramcar and other motor work.

It is difficult to measure even approximately the surface of the brush in contact with the commutator, and so I have taken the cross-section of the brush in the following list.

Maker.	Approximate section of brushes. sq. in.	Current.	Current density, amperes per sq. in.	Brush material.
Construction Corporation .	1·12	240	215	copper gauze
Ditto	2·25	370	165	,, ,,
Easton & Anderson	2·25	150	66	,, ,,
Gulcher	1·5	600	400	brass ,,
Johnson & Phillips	2·64	620	[redacted]	brass ,,
Siemens	6·00	1,600	267	copper ,,

From this it will be seen that a density of 250 amperes per square inch is about the general practice, as all these machines run without heating at the brushes; at full load this is an ample allowance.

Fig. 24.

Bearings.—This subject has been so well investigated by mechanical engineers that the proportions required to ensure cool running are now well known. There is a great uniformity in the general design of the dynamo bearings exhibited, and the length is usually three to three and a half times the diameter of the shaft. The question of the number of bearings to be used in a direct-coupled plant is still open.

The practice of coupling the armature directly on to the shaft outside the engine bearing, and so dispensing with the second dynamo bearing, is the most general plan. The advantages of this are that it is more easy to get perfect alignment in three bearings than in four, and the length of the whole plant can be reduced considerably. This reduction of floor space is of special value when the plant is to be used for shiplighting. The chief disadvantage is that any vibration of the engine due to knocking, etc., is communicated to the armature, and may in time develop a fault. The introduction of the second dynamo bearing helps to reduce this. With the disc type of armature the effect of vibration is apt to cause contact between the poles and the revolving armature. Hence the makers of this type invariably use the fourth bearing. To make up for any difficulty in alignment, and to prevent still more the transmission of the vibration of the engine to the armature, the Brush Company have introduced the Raworth flexible coupling, Figs. 24 and 25. This practically consists of two flexible drag links. Then if the shafts should be parallel, but a little out of line, the links act as in the case of an ordinary drag link and prevent any undue strain. Any want of alignment in any direction not parallel to the engine shaft is taken up by flexibility of the steel spring forming the links. This firm also show a somewhat similar coupling with solid links, but this does not answer so well as the above, as it compensates only when the shafts are parallel. Any other error gives rise to strains in the links.

The other coupling illustrated is an insulated one, manufactured by J. H. Holmes and Co. for their shiplighting plant, Fig. 26. This is for use with the single-wire system of shiplighting. With this system, when one terminal and the armature core are both connected to the ship, there is more likelihood of a short circuit occurring to the core. To overcome this possibility, the coupling is competely insulated, as shown. The hard disc fitting inside ensures that one half of the coupling shall be concentric with the other half. The dynamo bearing is also insulated, so that there is no electrical connection between the core and the ship.

Adjustable Bearings.—Two firms show dynamos fitted with ball and socket arrangement in the bearing to ensure evenness of wear. The Electric Construction Corporation use them in their motor-generator. The

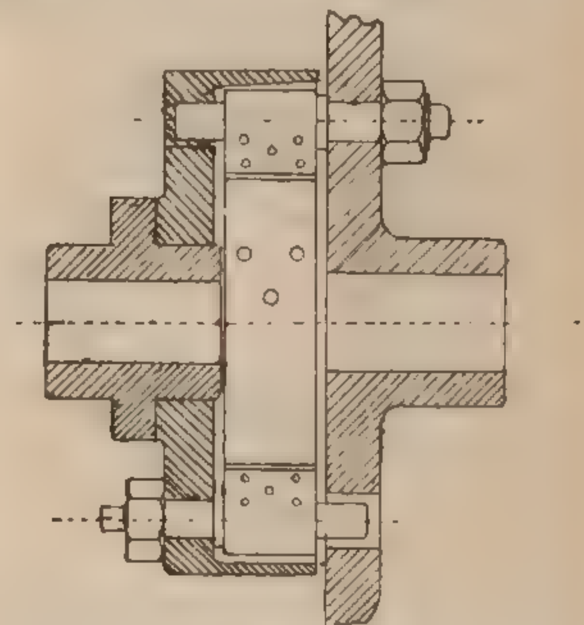


Fig. 25.

outsides of the gunmetal bushes have a spherical surface where they fit into the pedestal, and so allow the shaft to adjust the brasses till they are in line. This answers well in a belt-driven machine or a motor-generator. The

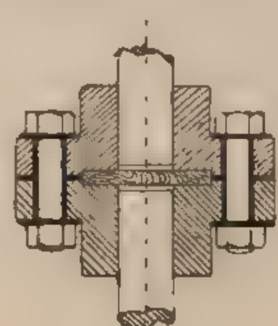


Fig. 26.

other firm, Messrs. Ronald Scott and Co., use a similar device in a direct-coupled dynamo, and it is very doubtful if they gain any practical advantage by so doing. When one end of the shaft is fixed the ball bearing cannot adjust for any error, except in a horizontal plane,

and errors of level are very likely to be introduced which cannot be compensated for.

The sight-feed principle of lubrication is most generally shown, but the Electric Construction Corporation have a good self-oiling gear attached to their motor-generators. It consists of a small force-pump fixed above the bearing and driven from an eccentric turned on the end of the shaft. The oil is delivered, as usual, to the upper side of the bearing. The oil, after passing the bearing, is drained off into an oil filter which is fitted in a recess in the frame of the machine. The circulation is good, and the filter must work well, as the same oil is used that was put in when the Exhibition was opened. The arrangement should ensure cool working when, as is intended, the motor-generator is placed in a sub-station without an attendant to look after it.

The Brush Company have a somewhat similar system, but that is fitted to a Mordey alternator, and will be described under that head.

THE RIES AND HENDERSON SYSTEM OF ELECTRICAL RIVETING.

The American electrical papers recently published the text of an important decision rendered by the United States Commissioner of Patents in the interference proceedings which have been pending for some years past between Mr. Elias E. Ries, of Baltimore, Md., and Prof. Elihu Thomson, of Lynn, Mass., in which the commissioner sustains, on final appeal, the original decision of the examiners of interference awarding the priority of invention on the broad art of electrical riveting, and for the apparatus for practising this art, to Mr. Elias E. Ries.

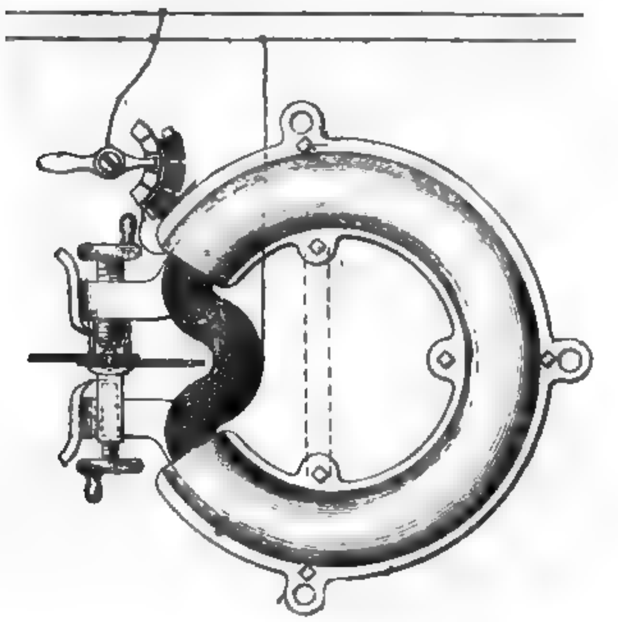


Fig. 1.

The interference proceedings were hotly contested on both sides, and brought together some of the best legal talent in the States, and the decision rendered gave Mr. Ries a virtual monopoly of the electrical riveting industry in America. Patents covering this system have also been taken out in England and elsewhere by Mr. Ries, who has done a large amount of work in connection with electric riveting and electrical welding in its various branches. He has also filed application for some very important detail patents in conjunction with his system of electrical riveting. We would refer parties wishing to look further into this matter to Mr. W. J. Hammer, who is the representative of the interests of Messrs. Ries and Henderson, at Stand 62, Crystal Palace.

Mr. Ries has taken out a large number of important patents in connection with electric welding. It is doubtful if any field for the application of this system presents a more commercial aspect, or is destined to meet with a greater application than his system of electrical riveting. It has already been applied to a wide range of work, and is found for many purposes to be far superior, as well as more economical and rapid, than the ordinary methods of riveting now in use, in which the rivets are first heated to incandescence and then carried to and inserted in the holes in the which they are headed. The advantage of being able to insert the rivet cold and heating it while in place to the exact degree of plasticity required to obtain the best results, the facility with which the heat is localised and controlled in the electrical process, as well as the ease with which the current may be transmitted along the line of a structure being riveted to any point at which the riveter may be at work and there converted to produce the local heat effect required, are features that cannot fail to produce a marked revolution in this important industry. In the accompanying drawing, Fig. 1, is a side elevation of one form of riveting machine embodying the invention in which the generating or inductional transformer forms the integral part of the frame of the machine. Fig. 2 is the side elevation of another riveting machine embodying features of this invention.

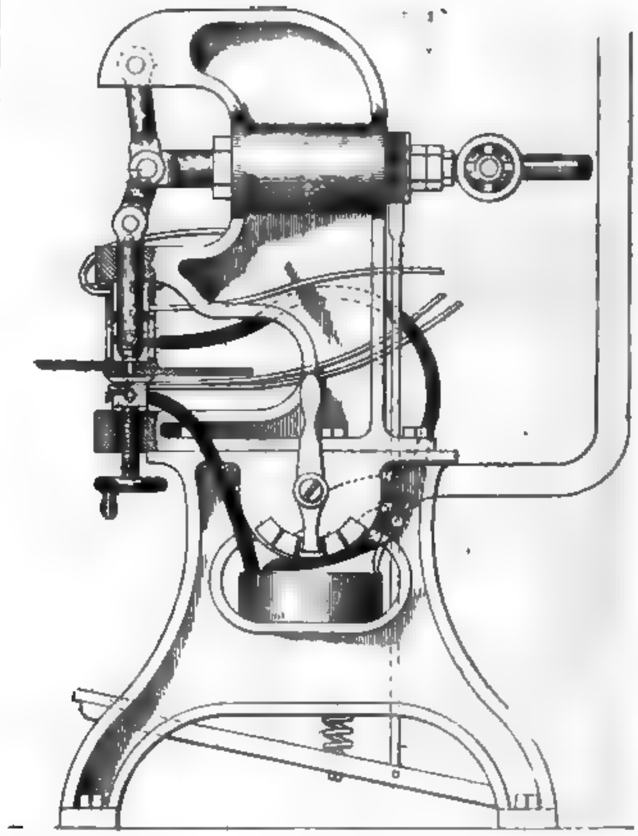
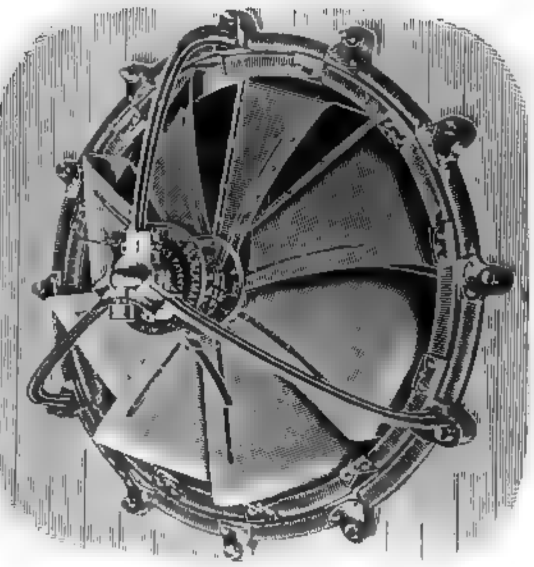


Fig. 2.

The Blackman Ventilating Company have several of their Blackman fans at the Crystal Palace, some driven by belting by means of small motors, and some combined with the motor as part of the fan itself. The latter form, of which we give an illustration, is worth a little attention from electrical engineers on account of the novel form of the motor employed. This is a multipolar motor with alternate poles in both field and armature, the armature being formed by the rim of the fan itself. There are only two brushes, and the motor runs on an exceedingly low consumption of current. The 3ft. fan shown at the Exhibition runs with one ampere at 107 volts, not very much more than is required for a 16-c.p. lamp. The 2ft. fan will run at a very high rate, up to 450 revolutions with one ampere. This arrangement is the invention of Mr. Watel, engineer to the company, and the motor makes a very light and efficient form. It is not claimed the design would be well for large motors, but for fans it seems excellent. The 3ft. motor weighs ½cwt. without the fan; the complete motor for the 12in. fan weighs only 13lb., and yet will work up to ⅛ h.p. without getting hot. The efficiency claimed is high; it is stated to be over 90 per cent. These motors do not

get hot, partly because of the continual stream of air around them, and also because of the high resistance to which they are wound. The great problem was to get the armature to run at all successfully at this diameter. The plan adopted seems very satisfactory, and we understand over 150 of these fans have been sold since last autumn, principally for banks, restaurants, and accumulator ventilators. Various small improvements are being introduced, such as the use of cast-iron cored commutators instead of fibre. The motors are wound to go on any circuit, and amongst the places where they are in use are the Holborn Restaurant, where there are two 18in. fans, London and Brazilian Bank (one 24in. for accumulator-room); the Savoy Mansions have two, the Houses of Parliament have the same number, and the Admiralty have adopted their use after trial, and they are being fitted on board H.M.S. "Royal Sovereign," where two 24in. fans are used for ventilation. They can also equally well be used for warming, and the Royal Institution is an instance where one 2ft. Blackman fan is used for warming. It is an interesting and comforting fact to be able to state that the Blackman Ventilating Co. report a large amount of trade already from their exhibit at the Crystal Palace Exhibition.



Blackman Electric Fan.

They find it the case with all exhibitions, and at the Paris Exhibition over 200 fans were ordered from their exhibit itself. All which is to show, for one thing, that exhibitions really are good for trade, and also that if the attention of the visitors is to be attracted, moving machinery of some kind is by far the best thing to do it. A striking show, if made moving, carries it own advertisement, and there is probably no one who has been to the exhibition who does not remember the rotating Blackman air propellers.

THE ELECTRIC MOTOR: A PRACTICAL DESCRIPTION OF THE MODERN DYNAMO MACHINE, MORE PARTICULARLY AS A MOTOR.*

BY W. B. SAYERS.

The object of the present paper is to describe the essential features of modern continuous-current dynamos, considered as motors, of the types more generally in use in this country—*i.e.*, the ring and the drum types—in such a manner as to render their mode of operation, and the essential conditions of satisfactory working, clear to mechanical engineers. In spite of the many able papers that have been read before this and other societies on the subjects of the dynamo machine, the electrical transmission of power, and kindred topics, I am not aware of any which have aimed at quite the same object as I have in view. They have all, I think, treated the subject either so deeply as to be understood and appreciated only by specialists, or so superficially as not to amount to a practical description at all. I shall try and steer between these two extremes. If an engineer has to put down a motor for any purpose he will naturally be shy of adopting one the principle of which is not at his finger ends, as is the principle of a steam, gas, or compressed-air motor. Every engineer understands the broad principles on which these motors work, even though the particular line of his profession has not led him to make a study of the properties of steam, of compressed fluids or hydraulics, or of the points to be considered in designing an economical motor of any kind. I venture to hope, then, that this paper, with the discussion of the subject which I hope may follow, will do something to assist those who have no desire or no time to make a special study of electrical engineering, to get grounded, if I may so speak, in the broad principles upon which electric motors depend for their action.

The conception of force impressed upon the piston of a steam or compressed air motor by fluid under pressure presents little or no difficulty to the mind. The force exerted by a fluid under pressure, or in rapid motion—though the fluid be invisible—is a phenomenon which is deprived of any trace of mystery by everyday experience. We frequently feel the force of the wind upon our bodies, or upon our umbrellas when we use them in a storm, and it requires no more than ordinary observation to tell us that air offers resistance to compression, and that, if compressed, it exerts force upon the sides of the vessel in which it is confined. But the force exerted upon a conductor in which an electric current is flowing, when the conductor is in a magnetic field, is a phenomenon for which there is no parallel in ordinary experience. The armature of an electric motor stands clear of the other parts of the machine, except at the bearings and brushes, and the torque is exerted upon it, across an air space, without the apparent intervention of any solid material. It is not suggested that the force is exerted without an intervening medium between the two bodies acted upon, or, in other words, that action is produced at a distance. How it is exerted or transmitted is a question the solution of which is undoubtedly involved in the question of the constitution and properties of the ether, a subject which is far beyond the province of my paper.

The Elementary Principle on which the Electric Motor Depends.—Suppose this bar, which is one square inch in cross-section and 39·37in., or one metre, in length, to be made of H.C. copper, and to be connected at its two ends with some source of electric supply, and so to have an electric current of let us say 100 amperes flowing through it. The effect of this current upon the bar would be that it would tend somewhat feebly to set itself in a plane at right angles to the direction of the earth's magnetic field—which is indicated at any spot by the direction taken up by the "dipping needle"—and there would be a small force acting upon it in a direction at right angles to the direction of the magnetic field and to the length of the bar. This force would be proportional to the strength of the field, to the length of the bar, and to the current flowing through the bar. The force would be due to the interaction of the electric current and the magnetic field. The magnetic field which pervades the surface of the earth is a very weak one, only from $\frac{1}{10000}$ to $\frac{1}{15000}$ of the strength or intensity commonly obtained between the poles of a dynamo machine or electric motor.

Fig. 1 represents an electromagnet which might be constructed to produce a magnetic field of about 10,000 C.G.S. units in the air gap; this is about 20,000 times (roughly speaking) the strength of the earth's magnetic field. It is a somewhat more intense field than usually obtains in the interpolar space or air gap in a dynamo machine or electric motor, but it is a convenient value for our present purpose.

The main body of the magnet would consist of a mass of wrought iron bent into the form of a link, and we will suppose it to be 39·37in., or one metre, deep—that is, one metre in the direction at right angles to the plane of the paper. Upon the two limbs of the mass, I have represented 17 turns of copper bar, wound on helically. The iron mass is not a continuous loop, there is an air gap ·79in., or two centimetres, wide. If we now suppose the copper

* Paper read before the Institution of Engineers and Shipbuilders in Scotland.

coils upon this mass of iron to be also connected with a supply source, and that a current of 1,000 amperes is thereby sent through them, the result would be that a magnetic flux would be produced through the iron mass and across the air gap of a density or a strength of about 10,000 C.G.S. units. That is to say, the magnetic field in the air gap, or interpolar space, would be rather more than 20,000 times as strong as the earth's magnetic field, which is a little under 0·5 C.G.S. units in this part of the world. If our metre bar carrying 1,000 amperes were placed in this space as represented in the diagram, it would be acted on by a force of 10^8 dynes, which is equal to about 224lb., in a direction at right angles to its length, as indicated by the arrow. The force would be independent of the velocity or direction of movement of the bar, so long as the conditions were maintained. The reversal of direction either of the current or of the magnetic field would reverse the direction of the force. It is upon the interaction between a conductor carrying an electric current, and a powerful magnetic field produced by an electromagnet, such as I have exampled, that an electric motor depends for its driving force. As I have before said, the force is proportional to the product of the length of the bar, L, by the intensity of the magnetic field, I, by the strength of the current, C. Thus, if C is in amperes, I in C.G.S. units, and L in C.G.S. units—that is, centimetres—

$$\frac{C \times I \times L}{10} = \text{force in dynes.}$$

$$\frac{1{,}000 \times 10{,}000 \times 100}{10} = 10^8 \text{ dynes; or}$$

$$\frac{1{,}000 \times 10{,}000 \times 100 \times 2{\cdot}2}{10 \times 981 \times 1{,}000} = 224\text{lb.}$$

A motor in which the driving bars were of this size would be a large one, as electromotors go at present, and the current I have spoken of, 1,000 amperes, is a large one. Such a motor having such a current in the bars, and their connections forming what we should call the armature circuit, would, if the supply pressure were 100 volts (a common figure for low-pressure supply), deliver about 230 h.p., and consume energy at the rate of about 205 Board of Trade units per hour.*

There is no absolute limit to the force which this bar could be caused to exert by increasing the strength of the current flowing through it, and the intensity of the magnetic field—for all practical purposes the limit of the latter is reached at about double the intensity we have assumed, or 20,000 units; but the current could be increased *ad lib.*, and the bar caused thereby to tear itself from any supports that could be devised. But in practice the force I have given—*i.e.*, 224lb.—is, roughly speaking, about the force which such a bar would be designed to exert in an economical motor when moderately loaded.

I will now ask you to glance briefly at the two distinct conditions under which energy of motion can be produced by a bar or wire carrying an electric current in a magnetic field. I have said that a conductor 39·37in., or one metre, long, carrying 1,000 amperes in a magnetic field of 10,000 C.G.S. units, would exert a force equal to about 224lb., which force would react upon the electromagnet producing the magnetic field. If we allowed the bar to move at the rate of 100ft. per minute, it would do work at the rate of 22·500 foot-pounds per minute, or about ⅔ h.p.; and, if we allowed it to move at 200ft. per minute, it would do work at the rate of 44·500 foot-pounds per minute, or 1⅓ h.p., and so on; while if it were fixed so as merely to exert a static force, it would do no work at all. Taking the last condition first—*i.e.*, that in which the conductor is fixed—the electric pressure or voltage required to produce 1,000 amperes through the bar, and which would have to be supplied from the source from which the current was derived, would be very small indeed, about 0·025 volt, and merely due to the inherent resistance of the bar to the flow of the electric current. If now, however, we allowed the bar to move, its own motion in the magnetic field would create a back pressure against the supply current driving it, consequently more pressure would have to be forthcoming from the source of supply if the current of 1,000 amperes and force of 224lb. were to be maintained. The inexorable law of the conservation of energy is, of course, herein fulfilled. The back pressure created in the conductor per unit of length would be doubled if the velocity of the bar were to be allowed to double, and would, in fact, be proportional to the velocity. These are the conditions which obtain in what is known as the constant-current system; in which system the pressure of supply is automatically varied, so as to keep the current constant under all normal demands.

The characteristic features with a constant current would be: (1) The force acting on the bar would be independent of the velocity at which it moved, and, in fact, would be constant; (2) the work done would be proportional to the velocity at which the bar moved; (3) the varying factor in the supply would be the pressure or voltage.

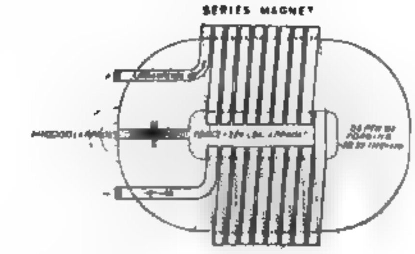


FIG. 1.

The second condition is that under which a constant pressure or voltage is maintained at the two ends of the bar, instead of a constant current being maintained through it, as in the first condition. The second is the condition which most frequently obtains in practice. It is characteristic of the constant-pressure system, and this is the system upon which electric energy is almost always distributed for lighting purposes, unless for arc lighting.

The electromagnet represented in Fig. 1 would be adapted for the constant-current experiment, and would be termed by an electrician a "series" magnet. For the hypothetical experiment we are now about to consider it would be better to use a magnet such as is represented in Fig. 2. Instead of the heavy copper coils, two bobbins are

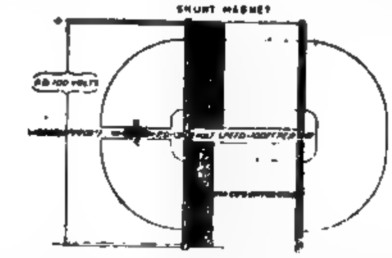


FIG. 2.

represented upon the magnet limbs. If these bobbins were wound with double-cotton covered high-conductivity copper wire of No. 11 S.W.G., and the ends connected one to either terminal of a constant-pressure supply of 100 volts pressure, the magnetic field produced in the air gap would be approximately the same as that produced by the 17 turns of bar, with 1,000 amperes flowing through it, in the first experiment. When an electromagnet is excited by a small independent current caused by maintaining a constant difference of pressure between the two ends of the exciting coils, it is called a "shunt" magnet; when by passing the main or working current through its exciting coils, it is termed a "series" magnet; and when both methods are used in conjunction, the magnet is said to be "compounded."

To proceed now with our second hypothetical experiment, using a shunt magnet, as represented in Fig. 2. Under normal conditions, if the bar were stationary, there would be no back pressure generated in it, and only the inherent resistance of the metallic conductor would limit the current which would flow if a difference of pressure

* The current in the armature conductors of any two-pole dynamo machine, whether as motor or generator, is half the total current passing. Hence the motor with 1,000 amperes in its conductors would take a total of 2,000 amperes, not reckoning the current required for exciting the magnets, which might be about 50 amperes.

were maintained between the two ends. The back pressure which would be generated in our motor bar when moving at the rate of 100ft. per minute, in a magnetic field of 10,000 C.G.S. units, would be $\frac{L \times I \times V}{10^8}$ = volts, where V is the velocity in centimetres per second. As 100ft. per minute $= \frac{100 \times 30 \cdot 48}{60} = 50 \cdot 8$ centimetres per second. $\frac{100 \times 10{,}000 \times 100 \times 30 \cdot 48}{10^8 \times 60} = 0 \cdot 508$ volt; and the corollary of this is that if we maintain a difference of electric pressure between the two ends a little in excess of this, the bar would be propelled through the magnetic field at the speed of 100ft. per minute. This would be a difficult experiment to make just in this form, because the bar would get out of the magnetic field in such a short time, but let us suppose that it could move a considerable distance without getting out of the field. As I have said, it would be propelled at the velocity of about 100ft. per minute. Through a considerable range this velocity would be maintained nearly independently of friction or any retarding force to which the bar might be subjected. This is an important fact, and will repay examination.

The speed at which it would be propelled could not exceed 100ft. per minute, because if it did the back pressure generated in the bar would equal or exceed the supply pressure—which we are assuming to remain constant at ·508 volt—and the result would be that the current would vanish or become reversed, and with it the driving force. Of course the bar might be forcibly held stationary, but if this were done, and if the difference of pressure could be maintained, which practically it could not, there would be a current of about 20,000 amperes through the bar, and it would exert a force of something like 2½ tons. This approximation to constant velocity with constant pressure is due to the great increase in the driving force, which a small reduction in speed brings about. In a steam engine a similar result is of course obtained by means of a governor; but in a constant-pressure, or "shunt," motor it is attained automatically.

To return to the bar with a constant difference of pressure between its two ends of ·508 volt. The electrical resistance of the bar, if made of high-conductivity copper, would be exceedingly small—about ·000025 ohm. Supposing it to be stationary in a magnetic field of 10,000 units, and the constant pressure of ·508 volt to be turned on. If the bar were unobstructed it would appear to start off instantly at the normal velocity of nearly 100ft. per minute instead of gradually getting up speed, the reason being that though the current would not have time to reach the value of 20,000 amperes before the motion of the bar had materially reduced the active pressure by inducing back pressure, yet the initial force would be so great as to practically amount to a blow, and would be so deftly administered as to start it just at the speed mentioned, so that the bar would appear to start off instantaneously at the ultimate speed of 100ft. per minute.

If we suppose the force required to drive the bar alone against the friction of rubbing contacts, or whatever we might devise to maintain the difference of pressure, to be, say, 5lb., the speed would be about $\frac{1}{10}$th per cent. below what it would be if there were no friction; again, the driving force would increase at the rate of (roughly speaking) 50lb. for every 1 per cent. which the speed was reduced by compelling the bar to do work.

It will fix ideas if we go through the simple calculation of these results. The force of 5lb., which we assume is required to drive the bar against the friction, would be produced by a current of $\frac{5}{224} \times 1{,}000 = 22 \cdot 2$ amperes. The amount of pressure required to cause this current through the bar is obtained by multiplying the current by the inherent resistance of the bar which would be ·000025 ohm. We have then:

$$22 \cdot 2 \times \cdot 000025 = \cdot 00055 \text{ volt.}$$

·00055 volt is required to send the current of 22·2 amperes through the bar. Now, equilibrium will only be possible when the remaining ·50745 volt of the supply pressure is opposed by an equal back pressure, and the back pressure is proportional to the velocity of the bar.

$$\cdot 508 - \cdot 00055 = \cdot 50745 \text{ volt;}$$

and ·50745 volt back pressure will be produced by a velocity of $\frac{\cdot 50745}{\cdot 50800} \times 100 = 99 \cdot 89$ft. per minute, at which speed the bar would run. If, now, we were to cause the bar to do work at the rate of about, say, 20,000 foot-pounds per minute, the retarding force on the bar would be approximately 205lb., or allowing a little extra for friction, say 207·5lb. The current required to exert this force would be $\frac{207 \cdot 5}{224} \times 1{,}000 = 927$ amperes.

$$927 \times \cdot 000025 = \cdot 0235 \text{ volt,}$$

which would be required to cause the current of 927 amperes to flow through the conductor. This gives us a balance of 0·485 volt to be opposed by back pressure $\frac{0 \cdot 485}{0 \cdot 508} \times 100 = 95 \cdot 7$ft. per minute.

To make the calculations strictly accurate, the rise of temperature of the bar caused by the current, and the disturbance which the current would cause in the magnetic field, would have to be taken into account; but the results obtained are sufficiently near the truth for our purpose.

The characteristic features with the constant pressure would be: 1. The speed of the bar would be maintained nearly constant under normal loads. 2. The work done would be proportional to the load. 3. The varying factor in the supply would be the current.

(To be continued.)

AZORES CABLE.

The following despatch from the *Times* Lisbon correspondent was refused transmission by the Portuguese telegraph authorities:

"Lisbon, March 31. The question of the cables from Lisbon to the Azores and the United States is giving rise to serious comment. It is openly stated that in non-fulfilling the contract signed with the British company the Government have committed a breach of faith, and that their reason for so acting was fear that the French would refuse to raise the loan mentioned in the proposals for the payment of the coupon in two years if they did not succeed in obtaining the contract to lay the cables. Notwithstanding that the Government have repudiated the contract they signed, they still hold out hopes to the British company of coming to an arrangement. I have reason to believe that the company, in order to lose no time, and to satisfy the demands of the Azorians, will immediately submit modified terms to the Government and request a prompt solution of the question. The proposals of the French company for laying the cables, which are published in the *Diario do Governo*, do not contain advantageous terms. They are brief and vague, and are only conspicuous for the statement that in treating with them the Portuguese Government will be relieved of the stipulations of articles 37 and 38 of the contract with the British company prolonging the privileges accorded on March 19, 1890, to the Eastern Telegraph Company for 10 years. Not only was the contract with the British company signed by the Minister of Public Works, but it was approved by the Parliamentary Committee appointed to report on it, and had not the Government pusillanimously given way to the intervention of the French Government, it would have been immediately voted by the Cortes, as a large majority of the deputies were desirous of settling the matter at once. I understand that the British Government has been fully informed of the proceedings in this matter."

Edinburgh Exhibition.—At a meeting on Wednesday of the contributories of the Edinburgh International Exhibition of 1890, Mr. J. Robertson, the liquidator, stated that the creditors would receive something like 17s. 6d. in the £, but that it was quite certain that the [illegible] would get nothing.

THE

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"EARTH."

Till the trial of the Lane Fox case we thought we understood the meaning of the term "earth," but when, in answer to Mr. Justice Smith on the very first day of the trial, Prof. Perry stated that "earth" "was the technical term for a return conductor, for a return however obtained—metal return wires were usually called earth"—preconceived notions were dispelled and chaos seemed nigh. When, further, the various witnesses on one side supported this contention, when some of the witnesses on the other side half-heartedly admitted it might be so, and the judge decided it was so, what could be said to the contrary. Galileo was convinced, except in the truthful aside, and we all know "that a man convinced against his will is of the same opinion still." Therefore, though it must be argued that we are legally convinced that "earth" in 1878 included "metallic returns," we do outside legal bounds remain equally convinced that the statement is utterly wrong, and absolutely contrary to the true facts of the case. We contend that up to the year 1878 "earth" never included the idea of "metallic return." On the contrary, its use excluded that idea. Let us look a little closer into this question. All the earlier telegraphic experiments were carried on with frictional electricity, and the earth was "used as the return circuit" (Sabine, p. 35). The earlier experiments with voltaic electricity all included the metallic return. It was not till Steinheil "made the important discovery," that it was known to electricians "that the earth might be used as part of the circuit of an electric current." This discovery was admitted—we had almost said is admitted—as "one of the greatest contributions ever made to the progress of the telegraph." As we have heretofore understood it, it was a great discovery because it showed how to decrease the resistance of the circuit and the cost of conductors. It was something better than metal, and to be used instead of metal. From the time of Steinheil down at any rate to 1878—we are emphatic upon the point—"earth" was a term to indicate the soil of the globe as a something that could be used in a telegraphic circuit *instead of* a return metallic wire. Up to the year 1878 a thousand experiments were carried out in directions telegraphic, to a hundred in any other direction; but we now come to one place wherein "earth" was used in a peculiar manner, and in a manner which gives some credibility to opinions contrary to those we held—we hold. Experience in laboratory working soon convinced a man that "good earth" was not easily obtained—that is, good electric contact was not easily made by connecting up with the gas or water pipes, or by burying plates of metal. Besides, "earth" was scarcely or never a requisite in laboratory work. Professors, lecturers, and masters explained that in their experiments they used a return wire instead of earth, and that in actual practical work such a wire would not be necessary, and would not be used, and for shortness sake the laboratory return was called "earth." We do not imagine that one student in a million ever understood the laboratory "earth" to mean anything more than "we cannot get earth

without a deal of trouble; therefore we rig up an experiment to show results, though in actual practice the earth—*i.e.*, the soil, and the soil only—would be used." There was not even a mental reservation that it might, under some circumstances, include "or equivalent metallic return." The metallic return meant the metallic return, and not a "wire return," *or* an "earth return." "Earth," then, prior to 1878, according to every book and periodical published, referred to something superseding metal, something better than metal. Yet because of its laboratory use for a makeshift return, we are to hold in 1892 that electricians up to 1878, when they used the term "earth," included the use of "metallic returns." Steinheil, Bain, Jacobi, Matteucci, Arago, Wheatstone, and scores of other eminent electricians, all wrote and spoke to prove the "earth return" a better return than the "metal return," and preferred the "earth" to the exclusion of "metal." If it was better, it could not be equivalent. We should be surprised to hear even in law courts an argument put forward that because a patentee had discovered a better method of constructing a pump than all previous inventors, that therefore his apparatus included not only what he described, but every material that might be substituted for any part of it, even though the materials were worse for the purpose than that described. Does the claim for the use of "soft metal" for bearings carry with it the use of every other material not so good as soft metal, because the shaft in the shop is run on gunmetal bearings, or cast iron or steel? We hold, then, that "earth" always had a definite meaning, and one not including metal in any shape or form. "Earth," in fact, meant something "not metal," the metal being used only to obtain contact. Unfortunately, the legal fiat has gone forth, and henceforth the legal fiction will be quoted as fact—according to which "earth" is in future to mean "soil" and "insulated" and "bare metal," all or either.

NOTTING HILL.

We suppose the report of the directors of this company is about as unsatisfactory as any report ever issued. There is evidently a lack of business capacity about the board which it will be well if the shareholders set about to remedy before it is too late. Everything relating to the welfare of the company is put in the most indefinite manner. Comparisons are made with other and more flourishing companies which are wholly beside the mark, the wasteful expenditure is very large, and the certain prospects of increased revenue unsatisfactory. The directors hitherto seem to have been doing that which they ought not to have done and leaving undone that which they ought to have done; in other words, expensive mains have been laid where there is no demand, and money is now wanted to lay mains where there is a demand. More harm has been done to electric lighting by such unbusiness-like methods than is pleasant to contemplate. Before large sums of money are expended there ought to be some indication of a return for such expenditure. Why, then, should £600 or £700 be expended in running a main through a certain quarter before ascertaining whether a single householder would be likely to patronise the light? The loss on seven months' working is admitted at £617, but it is stated that a good deal more current could be supplied with a very little increase of expenditure. With this view we beg leave to differ. It is perfectly certain that fuel, cartage, oil, stores, *proportion* of salaries, repairs, and such like items will increase almost proportionately with increased current, and a simple arithmetical calculation will show the long lane this company will have to traverse under present conditions before much profit can be made. It will be necessary to have an average of from 30,000 to 40,000 8-c.p. lamps on the circuit before the shareholders can hope for a dividend upon the existing capital, and if to obtain that number the existing capital has to be increased, so much the worse for the dividend.

CORRESPONDENCE.

'One man's word is no man's word,
Justice needs that both be heard."

THE LANE FOX CASE.

SIR,—In the recent case of Lane Fox *v.* Kensington and Knightsbridge Electric Light Company many of the witnesses, expert and otherwise, stated and tried to show that storage batteries do not regulate at all, or if they do, only momentarily.

The following practical example may be of interest on this point: Some years ago we were called in to advise as to an electric light installation fitted in a lonely country house in the South of Scotland. The dynamo was run by an overshot waterwheel, but owing to the defective construction of the wheel (the buckets of which were too small and allowed the water to rush over until the buckets filled again), about twice every minute the wheel raced away, unless controlled by hand; but on the first night of using the light about 100 out of 150 lamps were burned up, owing to this over-running, and the dynamo machine broke down. It was tried again and again, with like results, and the whole installation was a failure, and was given up as a bad job, and not used for over a year. We advised a set of storage batteries and an automatic switch. The work was put into our hands, and we re-arranged the whole system; we also put in one of our own dynamos, and from that day, over four years ago, the light has been in daily use and has been a great success. The fitting the storage cells at once cured the racing of the wheel, and the light is absolutely steady, so much so that is is not possible to say when it is being fed from the dynamo coupled with the storage batteries, or the storage batteries alone. Whilst charging, a fixed resistance is inserted between the lamps and charging current, and when the dynamo is switched off this resistance is automatically cut out, and the light is run from the cells for many hours, and there is no after regulation by switches.

This case appears to us to quite disprove the contention that storage batteries do not regulate of themselves.—Yours, etc., HENRY F. JOEL AND Co.

London, E.C., April 6, 1892.

CRYSTAL PALACE ELECTRICAL EXHIBITION.

SIR,—If the Hedgehog really intends to go one better and wipe the eye of the Sea Serpent he should be quick about it, as it will soon be time for all hands to pack up and clear out.—Yours, etc., X.

P.S.—My wife says she saw a large red egg somewhere, and wondered whether the crane laid it.

DYNAMO-ELECTRIC MACHINERY.*

BY J. HOPKINSON, F.R.S., AND E. WILSON.†

The following is intended as completion of a paper by Drs. J. and E. Hopkinson (*Phil. Trans.*, 1886, page 331). The motive is to verify by experiment theoretical results concerning the effect of the currents in the armature of dynamo machines on the amount and distribution of the magnetic field which were given in that paper, but which were left without verification. For the sake of completeness, part of the work is given over again.

The two dynamos experimented upon were constructed by Messrs. Siemens Bros. and Co., and are identical, as far as it is possible to make them. They are mounted upon a common base-plate, their axles being coupled together, and are referred to in this paper respectively as No. 1 and No. 2.

Each dynamo has a single magnetic circuit consisting of two vertical limbs extended at their lower extremities to form the pole-pieces, and having their upper extremities connected by a yoke of rectangular section. Each limb, together with its pole-piece, is formed of a single forging of wrought iron. These forgings, as also that of the yoke, are built up of hammered scrap iron, and afterwards carefully annealed. Gunmetal castings bolted to the base plate of the machine support the magnets.

The magnetising coils on each limb consist of 16 layers of copper wire 2 mm. diameter, making a total of 3,968 convolutions for each machine. The pole-pieces are bored out to receive the armature, leaving a gap above and below subtending an angle of 68deg. at the centre of the shaft. The opposing surfaces of the gap are 1·4 cm. deep.

The following table gives the leading dimensions of the machine:

	cm.
Length of magnet limb	66·04
Width of magnet limb	11·43
Breadth of magnet limb	38·10
Length of yoke	38·10
Width of yoke	12·06
Depth of yoke	11·43
Distance between centres of limbs	23·50
Bore of fields	21·21
Depth of pole-piece	20·32
Thickness of gunmetal base	10·80
Width of gap	12·06

The armature core is built up of soft iron discs, No. 24 B.W.G., which are held between two end-plates screwed on the shaft.

The following table gives the leading dimensions of the armature:

	cm.
Diameter of core	18·41
Diameter of shaft	4·76
Length of core	38·10

The core is wound longitudinally, according to the Hefner von Alteneck principle, with 208 bars made of copper strip, each 9 mm. deep by 1·8 mm. thick. The commutator is formed of 52 hard-drawn copper segments insulated with mica, and the connections to the armature so made that the plane of commutation in the commutator is vertical when no current is passing through the armature.

Each dynamo is intended for a normal output of 80 amperes 140 volts, at 880 revolutions per minute. The resistance of the armature measured between opposite bars of the commutator is 0·042 ohm, and of each magnet coil 13·3 ohms.

In the machine, the armature core has a greater cross-section than the magnet cores, and consequently the magnetising force used therein may be neglected. The yoke has the same section as the magnet cores, and is therefore included therein, as is also the pole-piece. The formula connecting the line integral of the magnetising force and the induction takes the short form—

$$4\pi nc = 2l_2\frac{I}{A_2} + l_3 f\left(\frac{\nu I}{A_3}\right), †$$

where

n is the number of turns round magnet.
c is the current round magnet in absolute measure.
l_2 the distance from iron of armature to rim of magnet.
A_2 the corrected area of field.
I the total induction through armature.
l_3 the mean length of lines of magnetic force in magnets.
A_3 the area of section of magnets.
ν the ratio of induction in magnets to induction in armature.
f the function which the magnetising force is of the induction in the case of the machine actually taken from Dr. J. Hopkinson on the "Magnetisation of Iron," *Phil. Trans.*, 1885, Figs. 4 and 5, Plate 17.

In estimating A_2 we take the mean of the diameter of the core and of the bore of the magnets 19·8 cm., and the angle subtended by the pole-face 112deg., and we add a fringe all round the area of the pole-face equal in width to the distance of the core from the pole-face. This is a wider fringe than was used in the earlier experiments (*Phil. Trans.*, p. 337), because the form of the magnets differ slightly. The area, so estimated, is 906 sq. cm.

l_3 is taken to be 108·8 cm.

A_3 is 435·5 sq. cm.

ν was determined by the ballistic galvanometer to be 1·47. It is to be expected that, as the core is actually greater in area than the magnets, ν will be more nearly constant than in the earlier experiments. It was found to be constant within the limits of errors of observation.

Referring to Diagram 1, the curve, C, is the curve $x = l_3 f\left(\frac{\nu y}{A_3}\right)$, and the straight line, B, is the curve $x = 2l_3\frac{y}{A_2}$, whilst the full line, D, is the characteristic curve of the machine—

$$x = 2l_2\frac{y}{A_2} + l_3 f\left(\frac{\nu y}{A_3}\right),$$

as given by calculation.

The marks + indicate the results of actual observations on machine No. 1, and the marks 0 the results on machine No. 2, the total induction, I, being given by the equation:

$$I = \frac{\text{potential difference in volts} \times 10^8}{208 \times \text{revolutions per second}}.$$

Experiments made upon the power taken to drive the machine under different conditions show that it takes about 250 watts more power to turn the armature at 660 revolutions when the magnets are normally excited than when they are not excited at all. The volume of the core is 9,465 cubic centimetres, or in each complete cycle the loss per cubic centimetre is $\frac{250 \times 10^7}{11 \times 9{,}465} = 24{,}000$ ergs.

The loss by hysteresis is about 13,000 (*Phil. Trans.*, 1885, p. 463) if the reversals are made by variation of intensity of the magnetising force, and the iron is good wrought iron. This result is similar to that in the earlier paper (p. 352), where it is shown that the actual loss in the core, when magnetised, is greater than can be accounted for by the known value of hysteresis.

Effects of the Current in the Armature.—Quoting from the Royal Society paper, p. 342, "The currents in the fixed coils around the magnets are not the only magnetising forces applied in a dynamo machine; the currents in the moving coils of the armature have also their effect on the resultant field. There are, in general, two independent variables in a dynamo machine—the current around the magnets and the current in the armature—and the relation of E.M.F. to currents is fully represented by a surface. In well-constructed machines the effect of the latter is reduced to a minimum, but it can be by no means neglected. When a section of the armature coils is commutated it must inevitably be momentarily short-circuited, and, if at the time of commutation the field in which the section is

* Paper read before the Royal Society.

† It must not be supposed from his name not appearing in this short paper that my brother, Dr. E. Hopkinson, had a minor part in the earlier paper. He not only did the most laborious part of the experimental work, but contributed his proper share to whatever there may be of merit in the theoretical part of the paper.—J. H.

† *Phil. Trans.*, p. 335.

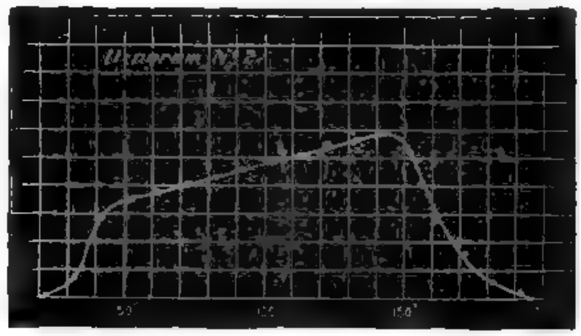
moving is other than feeble, a considerable current will arise in that section, accompanied by waste of power and destructive sparking.

"Suppose the commutation occurs at an angle λ in advance of the symmetrical position between the fields, and that the total current through the armature be C, reckoned positive in the direction of the resultant E.M.F. of the machine—*i.e.*, positive when the machine is used as a generator of electricity. Taking any closed line through magnets and armature, symmetrically drawn as A B C D E F A, it is obvious that the line integral of magnetic force is diminished by the current in the armature included between angle λ in front and angle λ behind the plane of symmetry. If m be the number of convolutions of the armature, the value of this magnetising force is $4\pi C\frac{m}{2}\frac{2\lambda}{\pi}=4\lambda m C$ opposed to the magnetising force of the fixed coils on the magnets. Thus, if we know the lead of the brushes and the current in the armature we are at once in a position to calculate the effect of the E.M.F. of the machine. A further effect of the current in the armature is a material disturbance of the distribution of the induction over the bored face of the pole-piece. The force along B C is by no means equal to that along D E. Draw the closed curve, B C G H B, the line integral along C G, and H B is negligible. Hence, the difference between force H G and B C is equal to $4\pi C\frac{m}{2}\frac{\kappa}{\pi}=2\kappa m C$, where κ is the angle C O G."

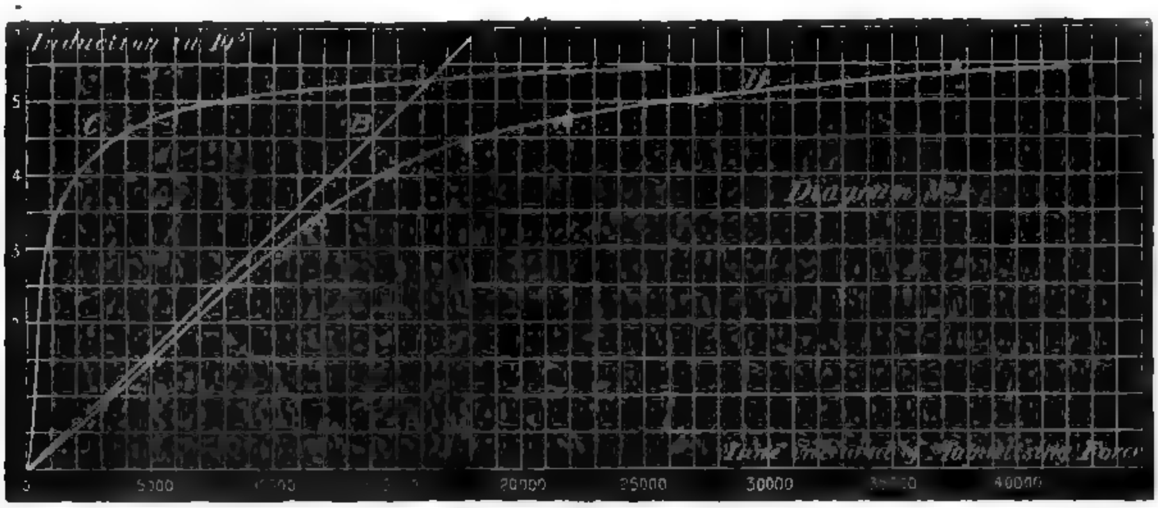
To verify this formula is one of the principal objects of this paper.

A pair of brushes having relatively fixed positions near together, and insulated from the frame and from one another, are carried upon a divided circle, and bear upon the commutator. The difference of potential between these brushes was measured in various positions round the commutator, the current in the armature, the potential difference of the main brushes, and the speed of the machine being also noted.

The results are given in Diagrams 2, 3, 4, and 5, in which the ordinates are measured potential differences, and the abscissæ are angles turned through by the exploring brushes. The potential differences in Diagram 2 were measured by a Siemens voltmeter, and each ordinate is therefore somewhat smaller than the true value, owing to the time during which the exploring brushes were not actually in contact with the commutator segments. But this does not affect the results, because the area is reduced in the same proportion as the potential differences. In Diagrams 3, 4, and 5, the potential differences were taken on one of Sir William Thomson's quadrant electrometers, and are correct.



Take Diagram 2 in which machine No. 1 is a generator. A centimetre horizontally represent 10deg. of lead, and the ordinates represent differences of potential between the brushes. The area of the curve is 61·3 sq. cm., and represents 130 volts and a total field of $\frac{130}{104}\times\frac{1}{29}\times 10^{8}=4{\cdot}31\times 10^{6}$ lines of induction. This is, of course, not the actual field, which is 3 per cent. greater on account of the resistance of the armature, but is represented by an area 3 per cent. greater. An ordinate of 1 cm. will represent an induction of $\frac{4{\cdot}31}{61{\cdot}3}\times 10^{6}=7{\cdot}0\times 10^{4}$ lines in 10deg. The area of 10deg. is 39·5 × 1·73 = 68·3 sq. cm.* Hence, an ordinate of 1 cm. represents an induction of 1,024 lines per square centimetre. The difference between ordinates at 50deg. and 140deg. is 2·5; hence the difference of induction is actually 2,560. Theoretically, we have $\kappa=\frac{1}{2}\pi$ $m=104$ $C=9{\cdot}4$. Therefore, $2\kappa m C=3{,}072$, and this is the line integral of magnetising force round curve.



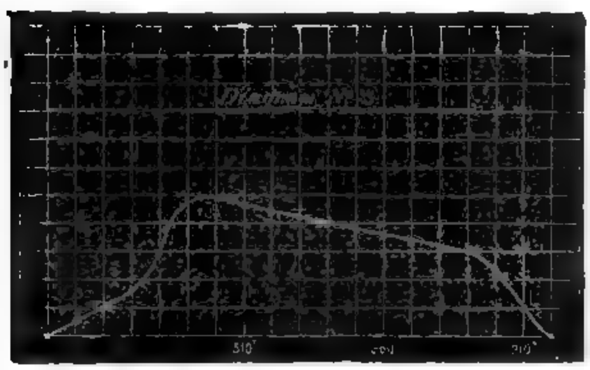
Let A be the induction at 50deg. and $A+\delta$ at 140deg.; these also are the magnetising forces. Hence, $(A+\delta)\,1{\cdot}4-A\,1{\cdot}4=2\kappa m C$; $\delta=2{,}200$ as against 2,560 actually observed.

Take Diagram 3, in which No. 2 machine is a motor. The total field $=\frac{107}{104}\times\frac{1}{20}\times 10^{8}=5{\cdot}15\times 10^{6}$ lines of induction.

* In calculating this area, the allowance for fringe at ends of armature is taken less than before, because the form of opposing faces differs.

Since the area of the diagram is 53 5 sq. cm., an ordinate of 1 cm. $= \frac{5\cdot15}{53\cdot5} \times 10^6 = 96 \times 10^4$ lines of induction in 10deg. Hence, an ordinate of 1 cm. represents an induction of $\frac{9\cdot6 \times 10^4}{68\cdot3} = 1{,}400$ lines per square centimetre. The difference between ordinates at 320deg. and at 230deg. is 2·0; hence the difference of induction is actually 2,800. Theoretically, we have $\frac{2\kappa m C}{l} = \frac{3\frac{1}{7} \times 104 \times 11\cdot4}{1\cdot4} = 2{,}666$ as against 2,800 actually observed.

In Diagram No. 4, No. 1 machine is a generator. The total field $= \frac{52}{104} \times \frac{1}{12\cdot6} \times 10^8 = 3\cdot97 \times 10^6$ lines. The area of the diagram is 90·9 sq. cm., and therefore an ordinate of 1 c.m. $= \frac{3\cdot97}{90\cdot9} \times 10^6 = 4\cdot37 \times 10^4$ lines in 10deg. Hence, an ordinate of 1 cm. represents an induction of $\frac{4\cdot37 \times 10^4}{68\cdot3}$ = 639 lines per square centimetre. The difference between ordinates at 50deg. and at 140deg. is 4·5; hence, the difference of induction is actually 2,787. Theoretically, we have $\frac{2\kappa m C}{l} = \frac{3\frac{1}{7} \times 104 \times 12\cdot9}{1\cdot4} = 3{,}010$, as against 2,877.



In Diagram No. 5, No. 2 machine is a motor. The total field $= \frac{63\cdot5}{104} \times \frac{1}{12\cdot3} \times 10^8 = 4\cdot96 \times 10^6$ lines. The area of the diagram is 112·2 sq. cm., and therefore an ordinate of 1 cm. $= \frac{4\cdot96}{112\cdot2} \times 10^6 = 4\cdot42 \times 10^4$ lines in 10deg. Hence, an ordinate of 1 cm. represents an induction of $\frac{4\cdot42}{68\cdot3} \times 10^4 = 647$ lines per square centimetre. The difference between ordinates at 323deg. and at 233deg. is 4·2; hence, the difference of induction is actually 2,718. Theoretically, we have $\frac{2\kappa m C}{l} = \frac{3\frac{1}{7} \times 104 \times 12\cdot3}{1\cdot4} = 2{,}870$, as against 2,718 actually observed.

At page 345 of the paper on "Dynamo-Electric Machinery" it is shown that

$$I + \frac{\nu - 1}{\nu} 4 \lambda \, m C \frac{A_2}{2 l_2} = F\left(4 \pi n c - \frac{4 \lambda m C}{\nu}\right),$$

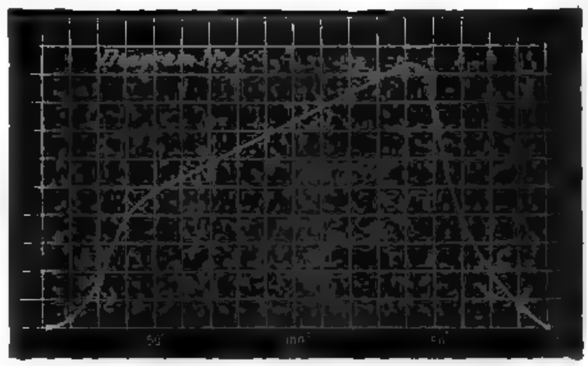
where $I = F\ (4\ \pi\ n\ c)$ is the characteristic curve when $C = 0$, and λ is the lead of the brushes.

The following is an endeavour to verify this formula The potentials both upon the magnets and upon the brushes were taken by a Siemens voltmeter, and are rough. The speeds were taken by a Buss tachometer, and there is some uncertainty about the precise lead of the brushes, owing to the difficulty in determining the precise position of the symmetrical position between the fields, and also to the width of the contacts on the commutator.

It was necessary, in order to obtain a marked effect of the armature reaction, that the magnet field should be comparatively small, that the current in the armature should be large, and the leads of the brushes should be large.

The two machines had their axles coupled so that No. 1 could be run as a generator, and No. 2 as a motor. The magnets were in each case coupled parallel, and excited by a battery each through an adjustable resistance. The two armatures were coupled in series with another battery and the following observations were made:

	Potential on magnets in volts.	Potential on brushes.	Speed per minute.	Current in amperes.	Lead of brushes.
No. 1 ...	24—24 ...	66—67 ...	880 ...	102—103 ...	26°
No. 2 ...	29—29 ...	86—84 ...	880 ...	102—103 ..	29°



From which we infer:

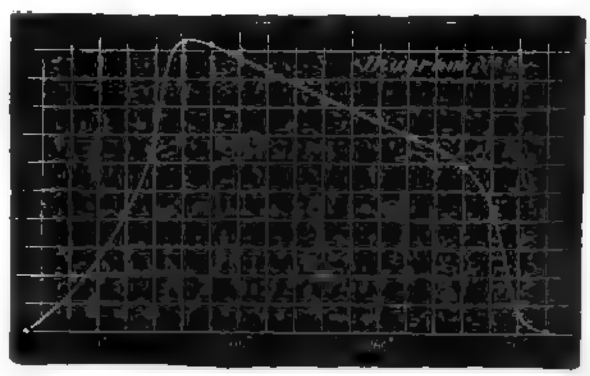
	Current in magnets.	$4 \pi n c$.	Corrected potential for resistance of armature.	Total induction I.
No. 1	1·78	8,900	70·8	$2\cdot30 \times 10^6$
No. 2	2·15	10,750	80·7	$2\cdot65 \times 10^6$

As there was uncertainty as to the precise accuracy of the measurements of potential, it appeared best to remeasure the potentials with no current through the armature with the Siemens voltmeter placed as in the last experiment. Each machine was therefore run on open circuit with its magnets excited, and its potential was measured.

	Potential on magnets in volts.	Potential on brushes.	Speed per minute.	Potential at 880 revs.
No. 1	25—25	90—90	880	90·0
No. 2	28—28	79—80	715—710	98·2

From which we infer, since we are upon a part of the characteristic which is practically straight; in which case, of course, the formula is reduced very nearly to

$$I = \frac{A_2}{2 l_2} (4 \pi n c - 4 \lambda m C).$$



	Potential on magnets.	Potential on brushes.	Induction $I = F (4 \pi n c)$.
No. 1	24	86·4	$2\cdot82 \times 10^6$
No. 2	29	101·7	$3\cdot30 \times 10^6$

We have further:

$\lambda = 0\cdot45$ for No. 1. $\qquad \lambda = 0\cdot5$ for No. 2

$$\frac{4 m C}{\nu} = 2{,}920 \qquad \frac{\nu - 1}{\nu} 4 m C \frac{A_2}{2 l_2} = 443{,}800.$$

It has already appeared that experiment gives for I in No. 1 $2\cdot3 \times 10^6$, and in No. 2 $2\cdot65 \times 10^6$. The difference is probably due to error in estimating the lead of the brushes, which is difficult, owing to uncertainty in the position of the neutral line on open circuit.

—	$\frac{4\lambda m C}{\nu}$.	$\frac{\nu-1}{\nu} 4\lambda m C \frac{A_2}{2l_2}$.	$4\pi n c - \frac{4\lambda m C}{\nu}$.	$F(4\pi n c - \frac{4\lambda m C}{\nu})$.	$F(4\pi n c - \frac{4\lambda m C}{\nu}) - \frac{\nu-1}{\nu} 4\lambda m C \frac{A_2}{2l_2}$.
No. 1	1,314	199,700	7,586	$2{\cdot}41 \times 10^6$	$2{\cdot}21 \times 10^6$
No. 2	1,460	221,900	9,290	$2{\cdot}90 \times 10^6$	$2{\cdot}68 \times 10^6$

AN INTRODUCTION TO QUALITATIVE CHEMICAL ANALYSIS.

BY BARKER NORTH, ASSOC.R.C.SC. (LOND.),

Joint Author of "Introductory Lessons" and "Hand-book of Quantitative Analysis."

(Continued from page 327.)

How to Make a Wash-bottle.

A large flask is taken which holds about one litre, and a wooden cork, which scarcely goes into the neck, is softened by rubbing gently under the sole of the foot till it fits tightly in the neck of the flask. The tubing to be used (about ¼in.) is now chosen, and two holes are bored in the cork, of the same diameter as the glass tube. A piece of tubing, about 5in. or 6in. longer than the height of the flask, is cut off, and bent in the fish-tail burner about 3in. from one end to an acute angle, as shown in Fig. 10. Another piece of tubing, about half the length of the previous one, is bent to an obtuse angle, so that the latter and the acute angle just make up 180deg. A short bit of glass tubing, about 3in. long, is drawn out in the middle, as shown at *a*, and cut into two pieces, one portion serving as a fine jet by being attached to the long bent tube by means of caoutchouc tubing. The sharp edges of all the tubes are fused up by holding in the Bunsen flame a few minutes, and the two bent pieces are introduced through the holes in the cork, which is afterwards fitted into the flask, and so gives us a wash-bottle as shown in Fig. 10. A layer of thick cord may also be wrapped round the neck of the bottle for holding it in the hand when the water is boiling.

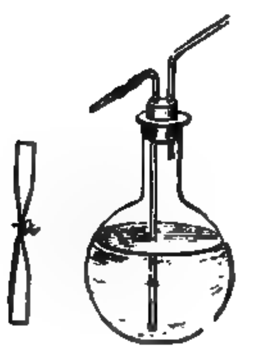


FIG. 10.

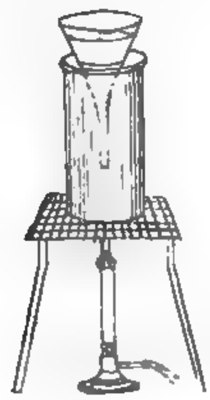


FIG. 11.

Washing the Precipitate.

In washing a precipitate, the jet of water should be directed round the top of the paper, so as to wash all the precipitate down into the bottom of the cone, and the water must never come above the edge of the paper, otherwise some of the precipitate will find its way down between the paper and the glass into the filtrate. Each washing should be allowed to drain off before filling up again with water.

Experiment 25.—Filter off the lead chloride obtained in Experiment 20, and wash several times with *cold* water. The precipitate may then be dried and preserved for future use in a bottle marked "Pure lead chloride."

How to Detach a Wet Precipitate from the Filter.

It will often be necessary to remove a precipitate from the paper on which it has been collected and washed, for the purpose of dissolving so as to apply further tests of indentification. There are many ways of doing this, which should be used discriminately according to the amount of the precipitate and the method by which it is proposed to treat it; thus, if there is a large quantity of precipitate a portion may be scraped off by means of a bone spatula or knife, whereas if the quantity of the precipitate is too small to treat in this manner, a hole may be made in the bottom of the paper by means of a pencil point or glass rod, and the precipitate then washed down into a test-tube or beaker by means of a jet of distilled water from the wash-bottle. Another method of doing this, instead of bursting the filter-paper, is to hold the funnel and paper inverted over a clean dish or beaker, and, by directing a jet of water on to the precipitate, thus wash the latter off the paper in the stream of water into the dish. When, however, it is desirable to prevent the precipitate from being mixed with water, the paper should be taken out of the funnel, opened out, and as much as possible of the precipitate carefully scraped off.

Drying Precipitates.

The student will sometimes have occasion to dry a precipitate after it has been thoroughly washed, especially if the precipitate has to be afterwards ignited. If a steam-drying oven is not in the list of apparatus at his command, the precipitate may be dried by the arrangement shown in Fig. 11. This merely consists of a tin can, about 4in. high, with one end knocked out and a circular hole cut in the other, so as to carry the funnel. This is supported during the drying operation on wire gauze over a Bunsen burner burning with a very small flame, so as not to burn the paper. By this means a precipitate may be dried much more quickly than in a steam oven, and for qualitative purposes quite as well.

FIG. 12.

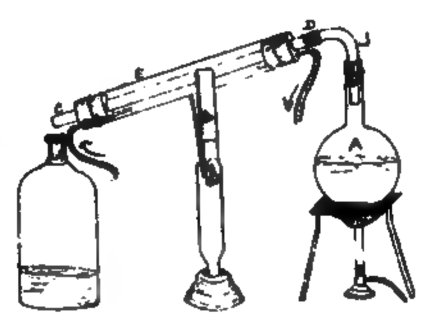


FIG. 13.

IGNITION.

The process of ignition is one which will have to be performed at times, and consists in subjecting the substance to be ignited to a very high temperature in a crucible or other convenient vessel. For this purpose the ordinary mouth blow-pipe may be used, but the process may be completed much more quickly by using the foot blow-pipe.

The Foot Blow-pipe.

In order to obtain a high temperature such as a white heat, a foot blow-pipe, such as is shown in Fig. 12, is indispensable. It consists of an ordinary bellows, A, worked with the foot, from which the air is forced into a reservoir, B, made out of an elastic bag covered with a net, which gradually forces the air through the aperture, C, in a constant stream into the air-pipe of the burner, D. In this it mixes with the gas, and gives a constant steady flame, which can be regulated by the two taps in the air and gas pipes respectively.

Experiment 26.—Prepare some cyanide of silver by adding silver nitrate to potassium cyanide in solution till a permanent precipitate is obtained. Filter off, wash well, and after drying ignite the silver cyanide in a porcelain crucible over the blow-pipe flame. The resulting substance will be found to be pure silver, which has been formed by the decomposition of the silver cyanide, and may be dissolved in warm dilute nitric acid.

Experiment 27.—Heat a little carbonate of lime or powdered chalk in the blow-pipe flame to a white heat for

several minutes in a small boat made out of platinum foil. Observe that after heating the chalk loses its property of effervescing when put into acid, as it has been converted from carbonate of lime to oxide of lime, thus: $CaCO_3 = CaO + CO_2$.

DISTILLATION.

It will be also well for the student to gain a little manipulation in distillation, and this may conveniently be done here in making distilled water. In making an analysis ordinary water should never be used, on account of the large amount of lime which it generally contains, and which would only confuse the student in some cases as to whether lime was present or not. The apparatus for the purpose of distillation has been simplified as much as possible, so as to come within the reach of those who are not able to provide themselves with the expensive stills usually sold for making distilled water.

How to Make Distilled Water.

Experiment 28.—The apparatus used for making distilled water is shown in Fig. 13, and may be fitted up according to the following description: A large flask, A, about 32 ounces capacity, is chosen, and furnished with a well-fitting cork, through which passes the stout piece of bent tubing, B. The latter enters a slightly wider tube, C, for a short distance, and is fastened into it by means of a piece of caoutchouc tubing, D. A wide tube, E, fitted with two corks, through which the tube C passes, serves as a cold-water jacket for the latter tube, a constant stream of cold water being supplied through a small delivery tube in the bottom cork, and carried away again by means of a small glass tube passing through the upper cork. The water in the flask is kept boiling, and the steam in passing down the central tube is condensed, and the water collected in a bottle placed at the bottom to receive it.

Distillation of Alcohol.

Experiment 29.—Alcohol may also be distilled in the same way, if necessary, and can be obtained from beer or spirits by distilling them in this apparatus. The alcohol, however, will in this case be mixed with more or less water, and in order to separate them the distillate will have to be submitted to fractional distillation.

Fractional Distillation.

In order to do this, a T-tube, A, Fig. 14, known as the

FIG. 14.

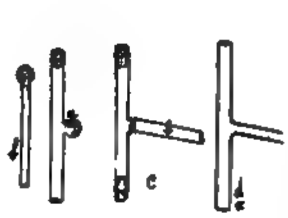


FIG. 15.

distilling-tube, will be required so as to be able to introduce a thermometer, B, for indicating the temperature of the distilling vapour.

How to Make a Distilling-tube.

A piece of soft glass tubing, about 7in. long and ⅝in. wide, is taken and one end tightly corked up. A small bulb, *a*, Fig. 15, is blown on one side by directing a small flame from the blow-pipe to a point about half-way up the tube till the glass is quite soft, and then blowing gently into the uncorked end. On the end of another piece of soft tubing, *b*, ¼in. in diameter and about 7in. long, a small bulb is similarly blown. The open end of the wider tube, *a*, is now tightly corked and the two bulbs broken, so that their edges, when fused up, will fit together, as shown at *c*. A very small flame of the blow-pipe is now directed to the two fused edges of the tubes, and by melting a small portion of the fused surface at a time so as to completely fuse the two together at that spot, the two surfaces may ultimately be fused so as to form one tube. Whenever the melted glass shows signs of collapsing, the operator must blow gently through the tube, *b*, but the junction should not be allowed to cool till the end of the operation, otherwise it will be very liable to crack.

When the distilling-tube, *d*, is made, it may be annealed by cooling slowly in the flame and then wrapping in cotton-wool, and in order to obviate as much risk as possible of this tube cracking, the two pieces of glass tubing should be made of similar glass so as to have the same coefficient of expansion.

Fractional Distillation of Alcohol and Water.

Experiment 30.—Alcohol boils at 78deg. C., and water at 100deg., but in distilling a mixture of the two the thermometer will gradually rise from 78deg. to 100deg. C. while the distillation is going on. That part distilling off at about 78deg. C. will be the richest in alcohol, at about 90deg. C. we shall obtain approximately equal amounts of alcohol and water, and the fraction at 100deg. C. will contain the most water. In the fractional distillation of alcohol and water we collect the distillate in several fractions; thus, in this case we might collect that coming over from 78deg. to 83deg., 83deg. to 88deg., 88deg. to 93deg., 93deg. to 98deg., and 98deg. to 100deg. C. in five separate flasks. When the whole of the liquid has distilled over, the first fraction, 78deg. to 83deg. C., is poured back into the clean flask and the distillation recommenced. The distillate is collected in the same flask as before, but the fraction distilling over between these two limits, 78deg. and 83deg., will contain more alcohol than in the first distillation, and some liquid will therefore remain in the flask. The second fraction is now added to this and again distilled. We shall now find some of this passing over between the first limit, 78deg. to 83deg., and this is collected in the first flask, but when 83deg. C. is reached the flask is replaced by the second one, which is empty, and the distillation carried on till we arrive at the upper limit of the second fraction—viz., 88deg. C. To the liquid remaining in the flask is now added the third fraction and the distillation carried on as before, taking care to collect the separate fractions always in their proper flasks. In this manner we shall continually add to the first and last fractions, and it will be noticed that the liquid is separating into two portions and collecting round the boiling points of alcohol and water. By repeating the fractional distillation a few times, we may ultimately obtain two fractions boiling fairly constantly at 78deg. C. and 100deg. C., but it is impossible to absolutely separate alcohol and water by this means, though with most liquids a perfect division can be thus effected.

Other liquids may be separated in this way, the number of degrees between the limits of the fractions being determined by the character of the mixed liquids.

Alcohol may also be prepared from ordinary methylated spirit, which is 90 per cent. alcohol with 10 per cent. wood spirit, by shaking with dry potassium carbonate and distilling, as shown in Fig. 13. Methylated spirit is generally used in analysis, but if it leaves a residue on evaporation it should be previously distilled.

Boiling Point of a Liquid.

The boiling point of a liquid may also be determined by the above apparatus, Fig. 14, but in very accurate cases a correction will have to be made for the expansion of the glass and for that part of the stem which is not immersed in the vapour.

(To be continued.)

HEATING OF DYNAMOS.

The radiation of heat from the surface of dynamos is treated by M. W. C. Rechniewski in *L'Electricien* for March 26. A dynamo, he says, is not like a gas or steam engine. The output from these motors is strictly limited, whereas a dynamo does not refuse the load above its normal, but simply heats until it burns up—that is, melts the insulation and produces a short circuit. In point of fact, what limits the output of most dynamos is the heating of the armature and magnets, and the capacity can usually be increased 20 or 30 per cent. by ventilating the armature. In most specifications the heating is required not to exceed 30deg. C. over that of the air, which appears sufficient, though 50deg. C. does not present danger. The question

of heating is therefore important, and as every maker of dynamos has to face this question, it is astonishing that no treatment of the problem has been published giving, for instance, the number of square centimetres of cooling surface allowed in the armature per watt of energy transformed into heat in its interior. This is more necessary, as experiments show that the constant varies from 1 up to 3, according to the geometrical form of the armature. For certain shapes 8 sq. cm. per watt is required, while for others 3 sq. cm. per watt is sufficient.

The work expended in the armature is thus calculated :

1. Work of current in wire $= V_c \rho \delta^2$, where V_c is total volume of copper on armature; ρ is specific resistance of copper, $1{\cdot}6 \times 10^{-6}$; δ, density of current per square cm.

2. Work of hysteresis $= V_i N \sigma$, where V_i is volume of iron in armature, subject to change of magnetism; N, number of complete cycles per second; σ, work of hysteresis per cm. cube and complete cycle. This latter depends naturally on intensity of magnetisation; it is taken in these experiments that it is proportional to the flux per cm. square, and that for a flux of 10,000 per cm.^{2} it is equal to 10,000 ergs per cm.^{3} and complete cycle. Experiment shows that it is sufficiently exact; Foucault currents are negligible, and the two sources of heat necessary to consider are those of resistance and hysteresis. This study takes into account only cases where the cooling surface of the armature is of greater importance than that of the field magnets. The trials lasted until the dynamo attained the required limit of temperature, determined each time by preparatory tests.

DRUM ARMATURES.—*Dynamo of* 3,300 *watts*: Volume of iron discs $V_i = 1{,}100$ cm.^{3}, of copper $V_c = 440$ cm.^{3}; density of current, $\delta = 500$ A. per cm.^{2}; speed 1,656 revolutions, whence $N = 26$; flux in armature 17,000 units, whence $\sigma = 17{,}000$ ergs $[1{\cdot}7 \times 10^{-3}]$.

The work Δ P transformed into heat in armature was therefore :

$$\Delta P = V_c \rho \delta^2 + V_i N \sigma.$$

$$\Delta P = 440 \times 1{\cdot}6 \times 10^{-6} \times 500^2 + 1{,}100 \times 26 \times 1{\cdot}7 \times 10^{-3}.$$

$$\Delta P = \quad 88 \quad + \quad 48 \quad = 136 \text{ watts.}$$

The cooling surface may be calculated as follows:

Surface of drum (20 cm. long × 12 cm. diam.)	= 720 cm.^{2}
„ two caps	= 230 „
Total cooling surface	= 950 cm.^{2}

The machine was run $2\frac{1}{2}$ hours, sufficient for the steady temperature of small machines to be attained as found by previous trials.

At the end of this time it was found: Temperature of exterior, 13deg. C.; of armature, 64deg. C.; excess of temperature, $\Delta t = 51$deg. And we have $\frac{950}{136} = 7$ cm.^{2} of cooling surface per watt expended interiorly as heat, the elevation of temperature being 51deg. C. For the increase of temperature not to exceed 50deg., the cooling surface should have been $\frac{51}{50} \times 7 = 7{\cdot}14$ cm.^{2} per watt.

2. *Dynamo of* 5,750 *watts*, 850 *revs.*—In this machine $V_i = 3{,}200$ cm.^{3}, $V_c = 1{,}100$ cm.^{3}, $\delta = 330$ A. per cm.^{3}, $N = 14$, $\sigma = 1{\cdot}7 \times 10^{-3}$.

Work transformed into heat:

$$\Delta P = V_c \rho \delta^2 + V_i N \sigma$$
$$= 1{,}100 \times 1{\cdot}6 \times 10^{-6} \times 330^2 + 3{,}200 \times 14 \times 1{\cdot}7 \times 10^{-3} = 193 + 76 = 269 \text{ watts.}$$

Surface of drum (l = 27 cm., d = 175 cm.	= 1,450 cm^2.
„ „ caps	= 550 cm^2.
Total cooling surface	= 2,000 cm^2

After $2\frac{1}{2}$ hours' working the t exterior was = 7deg. C., of armature = 53deg. Excess Δt = 46deg. In this case $\frac{2{,}000}{269} = 7{\cdot}4$ cm.^{2} per watt. For excess of 50deg. it would be sufficient to have $\frac{46}{50} \times 7{\cdot}4 = 6{\cdot}9$ cm^2.

3. *Dynamo* (R_{15}) *of* 26,000 *watts*, working at 200 A. and 79 V. at 590 revolutions as motor. $V_i = 10{,}980$ cm^3., $V_c = 2{,}880$ cm.^{3}, $\delta = 329$, N = 10, flux as before $1{\cdot}7 \times 10^{-3}$. Work comes to 683 watts. Surface (l = 42 cm., d = 27 cm.) 3,400 + caps 1,840 = 5,240 cm.^{2}. After four hours, t exterior 12deg., t of armature 61deg., excess 49deg. We have $\frac{5{,}240}{683} = 7{\cdot}65$ cm.^{2} per watt. For heating of 50deg. it would be $\frac{49}{50} \times 7{\cdot}65 = \sigma\ 7{\cdot}5$ cm.^{2} of cooling surface.

Dynamo (R_{15}) as above, with interior ventilation: 110 V., 300 A., 960 revolutions. $V_i = 9{,}150$, $V_c = 3{,}072$, $\delta = 470$. Cycles $N = \frac{960}{60} = 16$. Flux as before. Work expended = 1,332 watts. Surface as before. Ran for three hours, at end of which: t exterior 13deg., t of armature 67deg., excess of t 54deg. Whence $\frac{5{,}240}{1{,}332} = 3{\cdot}93$ cm.^{2} of exterior cooling surface per watt. For a heating of 50deg. we should require $\frac{54}{50} \times 3{\cdot}93 = 4{\cdot}25^2$ per watt. In this case the interior ventilation has increased the capacity of the armature $\frac{7{\cdot}5}{4{\cdot}25} = 1{\cdot}76$—*i.e.*, 76 per cent.

4. *Dynamo of Manchester type*, ring armature, 18,000 watts, 240 A., 70 V., at 1,000 revolutions. In this machine we have:

$$V_i = 12{,}300,\ V_c = 2{,}466,\ \delta = 350,\ N = \frac{1{,}000}{60} = 17,$$
$$\text{flux} = 1{\cdot}7 \times 10^{-3}.$$

Work expended in heating 485 + 324 = 829 watts. The armature was closed at one end by a metal plate, the cooling of exterior and two lateral surfaces only could be reckoned.

Surface (l = 27, d = 36 cm.)	= 2,970 cm.^{2}
„ lateral	= 1,880 „
Total surface	= 4,850 cm.^{2}

After four hours running: t exterior 16deg., t of armature 65deg., excess of t 49deg. Hence,

$$\frac{4{,}850}{829} = 5{\cdot}85 \text{ cm.}^2 \text{ per watt.}$$

For a heating of 50deg., we should have:

$$\frac{49}{50} \times 5{\cdot}85 = 5{\cdot}73 \text{ cm.}^2 \text{ of cooling surface per watt.}$$

5. *Dynamo, eight-pole type*, 36,000 *watts*. From the drawing the surface was calculated as follows:

Exterior surface of armature = $26 \times \pi \times 50$	= 3,900 cm^2
Interior „ „ „ = $26 \times \pi \times 25$	= 1,950 „
Two lateral surfaces	= 1,590 „
Total cooling surface	7,440 cm.^{2}

This machine is well ventilated at all parts, air entering easily round the shaft and escaping between the wires leading current to commutator. In this machine we have $V_i = 12{,}700$ cm.^{3}, $V_c = 5{,}040$ cm.^{3}. Flux in iron armature was 10,000 per cm.^{2}, whence $\sigma = \frac{1}{1000}$. Three tests were made with this machine.

A (*First test*).—Three hours' running at 120 V., 330 A., 690 revs., we then had: density of current δ = 300 A. Cycles per sec. $N = \frac{690}{90} \times 4 = 46$. Work expended in armature was therefore: $\Delta P = V_c \rho \delta^2 + V_i N \sigma$.

$$= 5{,}040 \times 1{\cdot}6 \times 10^{-6} \times 330^2 + 12{,}700 \times 46 \times \tfrac{1}{1000}.$$
$$= 1{,}060 \ + \ 590 \ = 1{,}650 \text{ watts.}$$

There was, therefore, $\frac{7{,}440}{1{,}650} = 4{\cdot}5$ cm.^{2} of cooling surface per watt transformed into heat in the armature. At the end of three hours: t exterior = 15deg., t of armature = 51·5deg.,

excess $\Delta t = 36\cdot5$deg. Therefore, for an excess of 50deg., it would have sufficed to have $\frac{50}{36\cdot5} \times 4\cdot5 = 3\cdot3$ cm^2. of cooling surface per watt.

B (*Second test*).—Three hours of running 490 revolutions, 75 volts, and 400 amperes. Under these conditions : $\delta = 400$, $N = \frac{490}{60} \times 4 = 32$. So that

$$\Delta P = 5{,}040 \times 1\cdot6 \times 10^{-6} \times 400^2 + 12{,}700 \times 32 \times \tfrac{1}{1000}$$
$$= 1{,}290 + 420 = 1{,}710 \text{ watts}$$

or $\frac{7{,}440}{1{,}710} = 4\cdot35$ cm.^{2} per watt expended.

At the end of three hours we had : t exterior 18deg., of armature 59deg., excess 41deg. For a heating of 50deg. we should have : $\frac{50}{41} \times 4\cdot35 = 3\cdot56$ cm.^{2} per watt.

C (*Third test*).—Four hours' running at 500 revolutions, 79 volts, 300 amperes. Under these conditions $\delta = 300$, $N = \frac{500}{60} \times 4 = 33$.

$$\Delta P = V_c \, \rho \, \delta^2 + V_i \, N \, \sigma$$
$$= 5{,}040 \times 1\cdot6 \times 10^{-6} \times 300^2 + 12{,}700 \times 33 \times \tfrac{1}{1000}$$
$$= 726 + 420 = 1{,}146 \text{ watts.}$$

We had, therefore, $\frac{7{,}440}{1{,}146} = 6\cdot5$ cm.^{2} per watt.

At the end of four hours' run we had : t exterior 15deg., t of armature 42deg., excess 27deg. For a heating of 50deg. we should have :

$$\frac{27}{50} \times 6\cdot5 = 3\cdot51 \text{ cm.}^2 \text{ of cooling surface per watt.}$$

The comparison of this with R_{15} is particularly instructive, the power of these machines being much the same. The open form of the multipolar ring results, not only in the utilisation of the interior surface for cooling, which would reduce the total dimensions, but the circulation of the air renders each square centimetre twice as effective as the drum form. The variation of peripheral speed does not play an important part in the cooling power, at least at the speeds tested.

This latter result must only be accepted within the limits of the tests, as it is evident that an armature revolving rapidly by reason of the ventilation it excites, is capable of losing more heat for the same excess of temperature than an armature at rest. As demonstration of this fact, a well-known fact may be cited. The temperature of an armature is generally higher 10 minutes after stoppage than at the moment of stoppage ; the contact of the hand is sufficient to observe this fact, which can only be explained by supposing the armature loses less heat per unit of time when at rest than when in motion.

LEGAL INTELLIGENCE.

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION v. KING, BROWN, AND CO.

The Compound-Winding Patent.

This appeal from a decision of the Scotch Court of Session, which involved a very important question with regard to patent machinery for generating electricity for electric lighting and other purposes, came before the Lord Chancellor, Lord Watson, Lord Herschell, Lord Macnaghten, and Lord Field, in the House of Lords, on Tuesday. The case was argued on behalf of the appellants last year, when judgment was reserved. Their Lordships now delivered judgment affirming the decision of the Scotch Courts and pronouncing against the validity of the patent.

The **Lord Chancellor**: This is an appeal against an interlocutor of the First Division of the Court of Session affirming the interlocutor of the Lord Ordinary, setting aside the patent, of which the appellants are the assignees, on the ground that the portion of the invention patented, with which, under the circumstances, it is alone material to deal, had been previously published. The patent so set aside is known as Brush's patent, and bears date the 16th of November, 1878, and the question in debate is whether a patent taken out by Mr. Samuel Alfred Varley in 1876 does or does not so anticipate the patent of 1878, of which the appellants are the assignees, as to make the latter patent bad. The patent has relation to the particular form of dynamo-electric machines, all of which have, and were known to have before the date of either patent, this principle in common—that they move magnets past coils of wire or coils past magnets with sufficient velocity to produce the desired result. It was also familiar knowledge before the date of either patent that a current of electricity sent round a bar of soft iron would render the bar of iron magnetic. Undoubtedly, the progress of electrical science has given rise to various forms of using that energy in which the two principles to which I have adverted have become important, and the practical application of them by means of different mechanical devices has for some time past exercised the ingenuity of practical electricians. One appears to have been the idea of making one wire go round the iron bar, make it and maintain it as a magnet, making the same wire go to perform whatever work it was intended to perform, and returning to the magnet, and thus the single current doing two things. The further step was made when what was called the shunt apparatus was invented. The current of electricity was divided into two. One stream, so to speak, was made to go round the iron bar, keeping it magnetic, while the other was led to do the work which it was required to do, and were rejoined after the work had been accomplished. Mr. Imray explains with great clearness what are the two principles called series and shunt winding. On the machine being revolved, he says, a wire wrapped round and round the magnet crosses over to another magnet, proceeds to do whatever work is required of it in what is called the external or working circuit, and goes back again after doing the work. It is called "series" winding because the coils of the electromagnet are in series with the external circuit—that is to say, it is one continuous wire. The current goes straight from start to finish. The whole electricity produced by the machine goes to excite the magnet and to the external wire, and straight from the one to the other. The weak point of it, said Mr. Imray, is this—that as soon as you break the external circuit you will cease to have an electric machine, because there is no current. In electrical language, that is spoken of as having the external circuit opened. When the external circuit is broken or opened, the current ceases to flow, and you do not have the advantage of any magnetising action by the current going round the magnets of the machine. In the same way, the more resistance you put in your external circuit—that is to say, the more work you ask your machine to do—the less current will flow through the external circuit ; and the more work you have, the less you will be doing towards the magnetising of your machine. Resistance in wire mainly depends—first, upon the character of the wire, and what metal it consists of ; secondly, upon its transverse section ; and, thirdly, upon its length. The longer the wire, the greater the resistance ; the smaller the section, the greater the resistance ; one kind of metal has more resistance than another. Roughly speaking, a short thick wire has much less resistance than a long thin one. Another form is what is called "shunt" winding, in which the difference is simply in the disposition of the wires. The current coming away is split into two. One portion of it goes to what has been called the external circuit, doing whatever is to be done, and having done that work returns to the machine, but without any actual contact with the magnets of the machine at all. The other portion goes straight to the magnet, is wrapped round it as before, and then returns to the brush, as it is called, without any contact with the external circuit at all. The strong point, says Mr. Imray, of this arrangement is that, whether the external circuit is open or closed, there is always magnetism in the wire capable of producing electricity, because the current is continually running through the shunt to the magnet. A defect in it is that some of the electricity is taken away from the external circuit which otherwise would go through it. One further explanation of Mr. Imray's becomes necessary to follow the question with which your Lordships have to deal, and that has reference to what Mr. Imray says is variously known as "electro motive force," "tension," "pressure," and "potential." "Potential" seems to be the word generally used, and means the intensity of pressure by which the electricity is caused to pass along a conductor. The advantage of what is called a compound winding, which is neither more nor less than a combination of the two previously described, the first being known as "series," the second as "shunt," and the one in debate as "series-shunt," or compound winding. The advantage of the arrangement is in producing a constant pressure or an equal volume, or an even current. It is difficult, except by finding analogies in other subjects of physical research than electricity, to convey the exact idea, but the advantage attained, at all events, is that when the work is changed in the outer circuit the amount of current that goes round the magnet is so changed that one compensates, or nearly compensates, for the other. Now, in the patent, patented in 1876, Mr. Varley says : "Part of the electricity developed by the machine is 'diverted'" (and the word is significant) "to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light. There are several well-known ways of doing this" (this has been the subject of very violent comment), "but the method I prefer is to wrap the soft iron magnets with two insulated wires, one having a larger resistance than the other. The circuit of larger resistance is always closed, and the circuit of less resistance used for the electric light. When the electric light is being produced the greater portion of electricity passes through the circuit of less resistance, which I term 'the electric light circuit,' maintaining the magnetism of the magnets and producing the light. When the electric light circuit is opened from any cause the electricity developed passes through the circuit of greater resistance only, and maintains the magnetism of the magnets." It is impossible to deny that, in the present state of electrical knowledge dealing with dynamos ; but that the description given undoubtedly does

disclose to anybody familiar with the principle of electro-dynamos and the medium by which the electric current is turned to account points to the very thing for which the patent was granted to Mr. Brush. But it is said that, for the purpose of judging of the novelty of the invention of 1876, one must, as nearly as one can, apply oneself to the knowledge existing at that date, and not apply what we have learned since, so as to interpret the language of the patent of 1876 by the light of later discoveries. I am not quite certain that I understand the application to this case of that principle of interpretation, which, however, I admit to be sound. The "series" was known, the "shunt" was known, and the language seems to me incapable of any other interpretation than that the patentee did mean to combine the two previously known systems. If he did, and disclosed the mode of doing it, the novelty of the later patent cannot be supported. I confess that I am unable to entertain a doubt that it was so disclosed. What he intended was, I think, conclusively shown by the original rough sketch produced. Distinguished electricians cavil at the mode of its disclosure, criticise the language (which is not, perhaps, the most felicitously chosen), and possibly suggest doubts as to what would have been the fate of Mr. Varley's patent if it had been attacked upon the ground of the insufficiency of the specification, but that is not the question to be determined here. The question is the disclosure of the invention, which consisted in the combination of two known forms of dynamo-electric machines. I doubt whether there is much to choose in clearness of exposition between the one patent and the other. I think it is certain that neither the one patentee nor the other had any very definite notion of the importance of the invention until a year or two later. The invention of the incandescent light brought into prominence the importance of an even, uniform, and continuous flow of the electric energy. I am, therefore, of opinion that the interlocutor appealed from ought to be affirmed. I have confined myself, however, in arriving at this conclusion to the specifications themselves, aided by scientific witnesses, in interpreting the scientific nomenclature in which the specifications are couched, and the explanations of the witnesses as to the operations produced by the different forms adopted. I designedly avoid giving any opinion upon the question of the user of Varley's machine. Many questions, to my mind, arise as to what publication there was from the use of that machine as a machine disclosing the mode by which the electric light was produced. But inasmuch as I have come to the conclusion that I have indicated, it is not necessary further to discuss the extent to which the use of the electric light by means of Varley's machine for the purpose of illustrating some submarine invention was such an exhibition or publication of it as would make a subsequent patent void. I therefore move your Lordships that the interlocutor appealed from be affirmed, and this appeal dismissed with costs.

Lord Watson: The appellants are assignees of Brush's patent of 1878 for improvements in apparatus for the generation and application of electricity for lighting, plating, and other purposes. The patent originally included two different dynamo-electric apparatus, now known respectively as the shunt and the series-shunt, but in 1882 the appellants, having become aware of the fact that their shunt-winding machine had already been fully described and claimed in Clark's patent of 1875, amended their specification by disclaiming that part of it which related to shunt winding, and limiting their claim to the series-shunt. In this appeal they complain of a decision of the First Division of the Court of Session, affirming an interlocutor of the Lord Ordinary, by which he reduced and set aside their letters patent as amended by disclaimer on the grounds, *inter alia*, that the series-shunt apparatus therein described had been published in Varley's patent of 1876, and also that there had been prior public user. Dynamo-electric machines are useful for various kinds of work, but are now chiefly employed for producing light. I shall, in so far as it may be necessary to describe such machines, refer to them as if they were used for the latter purpose. At the date of Clark's patent the only known variety of self-exciting dynamos was the series-winding apparatus, in which the current of electricity generated in the revolving coils, after it has passed through the commutator, is conducted to and round the magnets and thence to the lamps, from which it returns to the machine, thus forming a single electric circuit, which performs the double function of magnetising the magnets and doing work. In the shunt apparatus the volume of electricity, after it has passed the commutator, is divided into two unequal currents by means of a shunt, or bifurcation of the conducting wire, which is in itself a common device. The smaller current is then made to circulate round the magnets, whilst the larger is led to the lamps; and they are again united just before they re-enter the machine. So that these currents form two separate circuits—that of greater resistance maintaining the supply of electric force in the magnets, and that of lesser resistance producing light. The series-shunt-winding apparatus is, as its name imports, a combination of the two systems already described. Its arrangements are practically the same with those of the shunt-winding machine, subject to this modification—that, after bifurcation, the larger current, instead of being taken direct to the lamps, is, in the first instance, made to encircle the magnets. Accordingly, the smaller current serves for excitation only, as in the shunt system, whereas the larger current serves both for excitation and for work, as in the series-winding system. Whether the series-shunt system was first disclosed to the public by Varley in 1876, or by Brush in 1878, it seems to be certain that the real merit of the arrangement was neither understood nor appreciated until the subsequent discovery of the incandescent lamp. The efficiency of light produced by the incandescence of filaments of carbon depends upon the maintenance of a uniform and steady flow of electricity in the working circuit, which is now termed a constant potential. In the series and also in the shunt system the working current is liable to considerable variation; with this difference—that the same disturbing elements which in the one case cause a decrease, in the other occasion an increase of E.M.F. The combination of these opposite tendencies brings into play the principle of compensation, and makes it possible, by careful adjustment, to attain a more constant potential with the series-shunt than with either of its component systems. The terms of Brush's specification indicate that the patentee had not in his view the attainment of that high degree of constancy in the motive force which is desirable for the purpose of incandescent lighting. He points out that other machines were "not well adapted for certain kinds of work, notably that of electroplating," and then proceeds to describe his own in these terms: "I attain my object by diverting from external work a portion of the current of the machine, and using it either alone or in connection with the rest of the current for working the field magnets. I prefer the latter plan of the two, especially for electroplating machines." In other words he attains his object by using either the shunt or the series-shunt, but prefers the latter for electroplating. For other purposes than electroplating he does not suggest that the one system is in any respect greatly preferable to the other. As matter of fact it appears to be doubtful which of the two is most suitable for plating. Mr. Preece, one of the appellants' skilled witnesses, says: "Pure shunt is preferred in England for electroplating. In America the compound is preferred." In Varley's patent of 1875 no claim is made either for shunt or for series winding. The passage which has been held, by both Courts below, to anticipate the invention claimed by the appellants, is merely descriptive of the machines to which the arrangements claimed by Varley may be usefully applied, and is in these terms: "Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light. There are several well-known ways of doing this, but the method I prefer is to wrap the soft iron magnets with two insulated wires, one having a larger resistance than the other. The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light. When the electric light is being produced, the greater portion of electricity passes through the circuit of less resistance, which I term 'the electric light circuit,' maintaining the magnetism of the magnets, and producing light. When the electric light circuit is opened from any cause, the electricity developed passes through the circuit of greater resistance only, and maintains the magnetism of the magnets." In estimating the real significance of Varley's specification, it is necessary to consider what amount of information with respect to dynamo-electric apparatus ought to be attributed to persons who had an opportunity of reading it in the year 1876. The language used by the patentee must be construed with reference to the information then open to the public, and not in the light of subsequent discoveries. To my apprehension, it does not admit of doubt that a reader acquainted only with series winding might not attach the same meaning to the words used by Varley, as would naturally occur to one who was also familiar with the shunt, or with the shunt and series-shunt systems of winding. Since the hearing of this appeal, I have carefully perused the whole evidence adduced by both parties, in so far as it has any bearing upon the issue of prior publication. Of the respondents' evidence, it is sufficient to say that it is in entire accordance with the decision appealed from. The appellants' evidence consists of oral testimony by electricians of great eminence, and is directed mainly, if not wholly, to prove (1) that, on a fair construction of the specification of 1876, the words relied on by the Court of Session do not disclose either shunt or series-shunt winding, and (2), assuming them to do so, that the specification does not contain explanations or directions which would enable a workman of ordinary skill to construct either a shunt or a series-shunt machine. I need hardly say that it is for the Court, and not for the witnesses, to construe the terms of the specification; and that their evidence upon the first of these points is only material, in so far as it may supply scientific facts, which ought to be taken into account in arriving at the true construction of the instrument. There is one circumstance which, in my opinion, seriously affects the value of the appellants' evidence upon both points. The testimony of their witnesses was given upon the footing that, in 1876, Clark's invention of the previous year was still unknown, and that those who read Varley's specification could have no knowledge of any system other than series winding. Upon that assumption, it occurs to me that a reader, whether man of science or skilled workman, would probably have been at loss to discover what Varley meant, and might not have arrived at either shunt or series-shunt winding without some exercise of his inventive faculty. I am, however, unable to find any good reason for holding that Clark's shunt machine was unknown in the year 1876. It is true that in 1878 Mr. Brush had never heard of Clark's invention, and also that shunt winding was unknown to Sir William Thomson before 1879. But it appears to me that Clark's taking out a patent for his invention was, both in fact and law, a publication of it. I do not suppose that every electrician, however eminent, is by necessity personally cognisant of every invention patented within the bounds of his science; and the ignorance of two or more of them is unavailing to prove that the knowledge of others was equally defective. I cannot, therefore, avoid the conclusion that, in 1876, Clark's shunt-winding machine had been disclosed to the public, and must have been known to some, if not to all, electricians; and, consequently, that the controverted passage in Varley's specification ought to be construed on the

footing that shunt winding was known at its date. I do not think it necessary to deal with the conflict of testimony as to the sufficiency of Varley's specification for the guidance of a skilled workman. The Lord Ordinary was of opinion that the appellants had failed to prove that part of their case. But I agree with his Lordship, and with the learned judges of the First Division, in holding that the sufficiency or insufficiency of the specification for that purpose does not afford a crucial test of prior publication Every patentee, as a condition of his exclusive privilege, is bound to describe his invention in such detail as to enable a workman of ordinary skill to practice it; and the penalty of non-compliance with that condition is forfeiture of his privilege. His patent right may be invalid by reason of non-compliance; but it certainly does not follow that his invention has not been published. His specification may, notwithstanding that defect, be sufficient to convey to men of science and employers of labour information which will enable them, without any exercise of inventive ingenuity, to understand his invention, and to give a workman the specific directions which he failed to communicate. In that case I cannot doubt that his invention is published as completely as if his description had been intelligible to a workman of ordinary skill. Assuming as, in my opinion, I am bound to do, that Clark's invention was known in 1876, I have no hesitation in holding that Varley's specification sufficiently describes both the shunt and the series-shunt machine. The first sentence in the passage already quoted contains an accurate representation of shunt winding. The electricity developed by the machine is to be "diverted," which is the word used in the appellants' specification to denote bifurcation, into two parts— one for magnetising, and the "remaining portion" for producing light. These expressions plainly refer to a single current of electricity generated by the machine, which is to be split into two currents—one for excitation of the magnets and one for work—an arrangement which, according to the evidence, embraces all the essential features of a shunt machine. The sentences which follow appear to me to describe the series-shunt with equal accuracy. They commence with the statement that there are several ways of "doing this"—that is, of obtaining a circuit of excitation and an electric lighting circuit from a single current—by dividing it into two portions. The method preferred is to make both circuits pass round the magnets, that of greater resistance being employed for excitation only, whilst that of lesser resistance excites the magnets, and also does the work of lighting. The series-shunt is evidently treated as a mere modification of the shunt system; and I think it might be reasonably regarded in that light by the patentee. The alteration in the mechanical arrangement of the apparatus is in itself trivial; and the possibility of thereby obtaining such a constant potential as would, at a future date, suffice for the purpose of incandescent lighting was not present to his mind. There might, as one of the witnesses suggests, still remain room for a patentable improvement upon the series-shunt as described by Varley, consisting in an adjustment which would ensure a high degree of constant potential. No such possibility is indicated either by Varley or in Brush's patent of 1878. In the argument addressed to your Lordships, counsel for the appellants laid much stress upon these words occurring in Varley's specification: "The insulated wire composing the helices is connected to the insulated wire surrounding the soft iron magnets of the machine, and is usually inserted in the circuit of greater resistance." They maintained that the necessary result of giving effect to that direction would be to deprive the apparatus contemplated by Varley of all the characteristics of series-shunt winding. The point does not appear to have been pressed in the Courts below. At least it is not noticed by any of the judges. In the absence of evidence to support the appellants' contention, I have come to the conclusion that the adjustment thus indicated might effect the constancy of the volume of electricity conveyed by the electric light circuit, but that the apparatus would still be a series-shunt-winding machine. These reasons are sufficient to dispose of this appeal; and I desire to express no opinion upon the matter of prior public user. The argument of the appellants satisfied me that the question was one upon which I should prefer not to form any conclusion without hearing counsel for the respondents. I therefore concur in the judgment which has been moved by the Lord Chancellor.

Lord Herschell delivered judgment to the same effect, and the other noble and learned lords having concurred,

The judgment of the Court below was affirmed and the appeal was dismissed with costs.

SAVORY AND MOORE v. THE LONDON ELECTRIC SUPPLY CORPORATION.

The Grosvenor Transformer Station.

The appeal by the defendants against the injunction granted by Mr. Justice Kekewich restraining them from using their Grosvenor buildings and cellars as a transformer station, came on before Lords Justices Lindley, Bowen, and Kay on Thursday, 31st ult.

The case was settled upon the following terms: Dissolve the injunction, the defendants undertaking (1) not to use any room except the basement (which was admitted to be free from danger) for transformers until satisfying some person, to be agreed on by the parties, as to its safety for that purpose; (2) not to store inflammable materials in any room used for transformers; the defendants to pay the cost of the appeal and of the action.

Mr. Moulton, Q.C., and Mr. W. F. Hamilton were for the defendants—the appellants; Mr. Rigby, Q.C., Mr. Warmington, Q.C., and Mr. Vernon R. Smith were for the plaintiffs.

COMPANIES' MEETINGS.

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY.

The fourth ordinary general meeting of this Company was held at the central station, Richmond-road, Kensington, on Tuesday afternoon, the chairman, Mr. Henry Ramié Beeton, presiding.

The **Secretary**, Mr. H. St. John Winkworth, having read the notice convening the meeting,

The **Chairman** said: I assume that, in accordance with our practice on previous occasions, it is the wish of the meeting that the report and accounts be taken as read. That report and those accounts set out the main facts of the progress of the Company for the year 1891, and I think that the shareholders will probably agree with me that the result is at any rate comparatively satisfactory. From the accounts it is seen that the capital expenditure for the 12 months has amounted to £8,996. The increase in revenue has amounted to upwards of £3,300, which has been earned on a percentage of about 41, thereby reducing the percentage of expenses from 92 to 79. Now the profits would, of course, have been larger if the rate of progress during the year had been equal to that of the preceding year. Unfortunately, that has not been quite maintained. I find that on the 31st December, 1889, there were connected to the Company's mains 4,520 35-watt lamps, and on the 31st December, 1890, 13,665 similar lamps, showing an increase during the year of 9,145. On the 31st December, 1891, there were connected to the Company's mains 19,388 35-watt lamps, showing an increase during the year of 5,723. Since the close of the year 871 lamps have been connected, raising the total connected on 31st March to 20,259, and there is every indication from the orders in hand, and the general development of the district, that we shall have a satisfactory increase during the current year. The Company has, of course, benefited by the administrative economies to which I referred at the last general meeting as on the point of being introduced, and, in addition, it has benefited by improvements in the works which have been introduced as the result of greater experience and more perfect organisation. Now, the condition of things which these facts disclose will, I think, justify the assumption that any future increments of capital are likely to be employed at a high rate of productivity, and that after the claims of any new capital have been satisfied, a surplus will be left which will accrue to the ordinary shareholders. At our last general meeting I was able to announce to the shareholders that the negotiations which had been for some time on foot for the benefiting of our construction asset were on the point of conclusion. Although their consummation was delayed longer than I expected at the time, I am pleased to say that after protracted negotiation we have at length attained a participation in a contract with the Leeds and London Electrical Engineering Company, whereby, although this Company will not enjoy a large share of the profits of that undertaking, on the other hand, it will not be called upon to provide any funds or take any further risk. Moreover, we are guaranteed £525 a year for the first two years, and if the business is as successful as it promises to be, we may get more than this for many years. With these few observations, I beg to move that the report and accounts be adopted.

Mr. Robert Hammond, managing director, had great pleasure in rising to second the resolution. There was little to add to the Chairman's extremely lucid exposition of the present position of the Company's business. He thought, however, shareholders would be interested to know that the rate of increase during the year would have been much larger if the plant had permitted the engineers to take on more business. They had been somewhat limited during the year by their plant, and the active canvassing for business which went on in the previous year was not continued in 1891, so that they might very fairly say that in the coming year, when further plant would be added to that at present in the station, they would have a considerable number of lights added to their circuit. In connection with this, he would also venture to draw the attention of shareholders to the fact, which was not emphasised from the chair, that since those accounts were closed an amount of preference capital had been issued and very freely taken up. The amount was £12,290, which would be spent in the works and used in increasing their possible output. The Chairman was, he thought, fully justified in what he said with regard to the good prospects that laid before the Company. The profits that had been made during the past year had been made upon a load that had gradually increased. The speaker then called the attention of the meeting to a diagram on the walls, on which curves were drawn showing the increase in the load. In June, 1890, it rose from 8,000 lamps to 20,000 at the end of March, 1892. The maximum output in 1890 was shown to be 210 kilowatts, and this year 264 kilowatts. He was sure Directors were not taking too sanguine a view of the future when they said that a point had been reached in the Company's history when they had got on a dividend-paying basis. He would congratulate the shareholders on the present position of the Company, and would thank the manager and staff, as well as the Director who had specially devoted himself to the works, for this condition of affairs. As to the interest that the House-to-House Company had in the Leeds and London Electrical Engineering Company, it might be known to most of them that the latter company was formed for the purpose of dealing efficiently with the so-called construction asset of the House-to-House Company, it being felt that it would be more to the interest of that Company to devote all its energies to the supply of electricity from house to house, and to leave to another company that might be able to manufacture machinery

the erection of central stations for others. He was very glad indeed to say that though that agreement was only finally made on the last day of last year, the Leeds and London Company, of which he was a director, had met with very great encouragement. He would draw their attention to a notice which appeared in a Midland paper on the previous day, to the effect that at the meeting of the Burton-on-Trent Corporation on Wednesday (April 6), the Electrical Committee intended to recommend that the contract for the erection of the central station for Burton should be given to that particular firm which was working on behalf of the Leeds and London Company, with the result that the profits thereby accruing would come into the pockets of that company. As the House-to-House Company had a very early charge upon those profits, the fact that that work had been taken would make them hope that the £525 alluded to by the Chairman would certainly this year be £1,050, if not more. He was also glad to inform shareholders that the Yorkshire House-to-House Company, which was one that also brought grist to the mill of the Leeds and London Company, had had a very satisfactory amount of capital subscribed, and would, he thought, result in a very good profit to that company, with which they were practically in affiliation. In conclusion, he could only say, as he had said so often, that an electric light company which did its work as well as the House-to-House did might depend upon a gradually increasing business. Those companies which had failed in the race were those that had not been able to satisfy their customers by giving a good light at a regular pressure. Those who moved about London and had an opportunity of comparing the light given by the House-to-House Company with that given by other companies, would agree with that Board in saying that there was no electric light company in the metropolis which was so satisfactorily fulfilling its obligations to its consumers as the House-to-House. Though in a position to hear complaints, he was glad to tell the shareholders that he only heard praises of their lights on every side.

Mr. Kimber asked how it was that in one account their capital was stated as being £41,610, and in another £26,610. He also called attention to one or two mistakes in the accounts which, he concluded, were misprints; and the Chairman said that was so.

Mr. Hammond explained that, under the Board of Trade rules, they had to keep two capital accounts, one relating to the House-to-House Electric Light Supply Order, 1889, and the other referring to the Company's capital.

The **Chairman** then put the resolution adopting the report and account, and declared it carried.

On the motion of the **Chairman**, seconded by **Mr. Davies**, a dividend at the rate of 7 per cent. on the preference shares was declared.

Mr. Hammond moved the re-election of Mr. H. R. Beeton as a director, this was seconded by **Mr. Page**, and carried.

The **Chairman** then proposed the re-election of Mr. Robert Hammond as a director, **Mr. Leese** seconded, and this was carried.

Mr. W. F. Leese and Mr. William Reginald Davies were then elected to the Board. Mr. Leese and Mr. Galindez were elected directors by the Board during the past year, but the Chairman explained that the latter had been obliged to go abroad, where he was likely to remain for some time, and under the circumstances did not offer himself for election.

The auditors (Messrs. Theobald Bros. and Miall) having been re-elected auditors on the proposition of **Mr. Kimber**, seconded by **Mr. Whitehead**, the proceedings closed with a vote of thanks to the Chairman.

TELEPHONE COMPANY OF EGYPT.

The ninth ordinary general meeting of this Company was held on Tuesday at the offices, Austin-friars, General Alexander Fraser presiding.

The **Chairman** said that the business generally had continued on the even course it had done for some years past, enabling them to pay a dividend of 6 per cent. on the preferred shares. The increase in the number of subscribers was sometimes discounted by a demand for lower rates, but this demand they had been forced to resist when they thought that the rates were as low as an efficient service would permit, and in the absence of all complaint he thought they were justified in considering that it was efficient. He concluded by moving the adoption of the report and accounts and the declaration of the dividend recommended.

Mr. H. Growing seconded the motion, which was carried.

NEW COMPANIES REGISTERED.

Chelmsford Electric Lighting Company, Limited.—Registered by E. H. F. Reeves, Little Heath, Potter's Bar, with a capital of £10,000 in £1 shares. Object: to carry into effect an agreement made between Messrs. Crompton and Co., Limited, of the one part and this Company of the other part, and generally to carry on business as manufacturers of and dealers in lamps and lanterns and other appliances for supplying light and power by means of electricity, and as electricians and mechanical engineers, etc.

The Pontypool Electric Light and Power Company, Limited. This Company has been registered by Waterlow Bros. and Layton, Birchin-lane, E.C., with a capital of £10,000 in £5 shares. Object: to carry on the business of an electric light and power company in all its branches. There shall not be less than five nor more than seven Directors; the first are W. Pegler, jun., J. C. Howell, E. B. Ford, W. Sandbrook, and J. Herbert. Qualification, £50.

BUSINESS NOTES.

Direct Spanish Telegraph Company.—The receipts for March were £2,103, as against £1,930 for the corresponding period of last year.

Eastern Telegraph Company.—The receipts for March were £59,037, as against £58,447 for the corresponding period of last year.

West India and Panama Telegraph Company.—The estimated receipts for the half-month ended March 31 are £3,047, as compared with £3,406.

Islington.—It is stated that the Islington Electric Lighting Company is being privately underwritten, and will be issued shortly to the public.

Private House Lighting.—Mr. W. H. Baxter, of 71, Gelderd-road, Leeds, is inviting tenders for supplying and fixing electric lighting plant in a private house.

Western and Brazilian Telegraph Company.—The receipts for last week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £3,265.

Globe Telegraph and Trust Company.—Interim dividends of 3s. per preference share and 2s. 6d. per ordinary share have been declared by the Directors, payable on the 20th inst.

The Telephone Company of Austria has declared the usual half-yearly dividend to the 31st ult. on the preference shares at the rate of 6 per cent. per annum, payable, less income tax, forthwith.

City and South London Railway.—The receipts for the week ending 4th April were £796, against £901 for the corresponding period of last year, which, however, happened to be Easter week. This represents a decrease of £105, as compared with the receipts for the week ending March 27. Those of last week show a decrease of £22.

W. T. Henley's Telegraph Works.—Warrants were posted on the 1st inst. for a dividend at the rate of 7 per cent. per annum on the preference shares and of 5 per cent. per annum (free of income tax) on the ordinary shares for the year ended December 31, 1891. The subscribed share capital of this Company is £21,000 preference shares and £67,270 ordinary shares.

Notice of Removal.—Messrs. Wheatley Kirk, Price, and Goulty, consulting engineers, valuers, arbitrators, and electrical and mechanical auctioneers, late of 52, Queen Victoria-street, E.C., inform us that the increase in their business having necessitated enlarged office accommodation, they have removed to 49, Queen Victoria-street, E.C. (Albert-buildings), immediately opposite the Mansion House railway station.

Personal.—Mr. Ernest Scott, consulting chemist and engineer, of 4 and 5, Investment-buildings, 67, Lord-street, Liverpool, informs us that he has taken over the business of Mr. Hugh Hughes, analytical and consulting chemist, of 20, Castle-street, which business he will carry on at the above address. Mr. Scott has for the past six years been head chemist and departmental manager to Messrs. Lever Bros., of Port Sunlight.

Bengal Telephone Company.—The report for the year 1891 shows that the position of this Company is steadily improving. An available balance amounting to 54,676 rupees is shown at the credit of profit and loss account, out of which it is proposed to pay a dividend at the rate of 5½ per cent., and to carry forward 6,276 rupees. The report states that on the 31st of last December the Company's revenue had amounted to 78,155 rupees, the largest on record. The dividend declared is at the rate of over 9 per cent. on the present value of the scrip.

Eastern Extension Telegraph Company.—The accounts to December 31 last show, subject to audit, a balance of profit of £198,237, after payment of three interim dividends. The Directors now propose to distribute on May 4 next the usual dividend of 2s. 6d. per share, making a total dividend of 5 per cent. for the year 1891, together with a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year. The balance of £111,987 has been carried to the reserve fund. The receipts for March amounted to £43,805, as against £44,716 in the corresponding period of last year.

Companies Registered during March.—The following electrical companies were registered during the past month:

Association for the Protection of Telephone Subscribers, Limited (Guarantee)	—
Boardman's Electric Sun Lamp Patents, Limited, £5 shares	£10,000
Chelmsford Electric Lighting Company, Limited, £1 shares	10,000
Electric Lighting and General Development Syndicate, Limited, £10 shares	700
Hick, Hargreaves, and Co., Limited, £10 shares	240,000
Merryweather and Sons, Limited, £10 and £1 shares	110,200
Pontypool Electric Light and Power Company, Limited, £5 shares	10,000

PROVISIONAL PATENTS, 1892.

March 28.

5971. **Improvements in underground conductors for the distribution of electricity.** Sydney William Baynes, 37, Spring-gardens, Manningham, Bradford.

5982. **Improvements in joints and connections for electrical purposes.** Aymor Holloway Sanderson, "Darfield," Marlborough-road, Bournemouth.

5988. **Improvements in or relating to the distribution of electricity.** John Smith Raworth and William Geipel, 46, Lincoln's-inn-fields, London.

6006. **Improvements in the treatment of electro-deposits of metals.** Thomas Parker and Alfred Edward Robinson, 47, Lincoln's-inn-fields, London.

6007. **Improvements in or connected with cells for electrolysing chloride solutions.** Thomas Parker and Alfred Edward Robinson, 47, Lincoln's-inn-fields, London.

6015. **Improvements connected with shades and shade or reflector holders for incandescent electric lamps.** Richard Robert Harper, 166, Fleet-street, London.

MARCH 29.

6050. **Improvements in insulated electric conductors.** William Phillips Thompson, 6, Lord-street, Liverpool. (James B. Williams, United States.) (Complete specification.)

6058. **Improvements in machinery for the purpose of hardening and tempering metals by electricity.** William Frederick Taylor, Boswell-court, Croydon.

6061. **Improvements in telephone switchboards.** Alfred Whalley, Helsby, near Warrington, Cheshire.

6083. **Improvements in incandescent electric lamps.** Frank Stuart Smith, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

6088. **Improvements in the manufacture of filaments for incandescent electric lamps.** Moritz Boehm, 18, Buckingham-street, Strand, London.

6095. **Improvements in conductors for electric railways or tramways.** Reginald Belfield, 6, Waldegrave-park, Strawberry Hill, Middlesex.

6105. **Improved method of and apparatus for lessening or preventing incrustation, corrosion, and pitting in steam generators, and apparatus for imparting heat to water, which invention can be applied in connection or not with electric lighting apparatus.** James Bennett and John Tellefsen, 46, Lincoln's-inn-fields, London.

6112. **Improvements in and relating to secondary batteries or accumulators.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (William Sleicher, jun., and George Abija Mosher, United States.) (Complete specification.)

6119. **Improvements relating to electric railways.** Michelangelo Cattori, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

MARCH 30.

6122. **An improvement in the construction of electric arc lamps.** Edwin Charles Russell, Jeffreys-square, St. Mary Axe, London.

6145. **An improved electric railway system.** Eben Moody Boynton, 52, Chancery-lane, London.

6152. **An improved material or fabric for applying magnetic, galvanic, or other currents for curative or medical purposes.** Thomas Field, jun., James Worsfold, and Henry Samuel Deffett Brayn, 82, Mansion House-chambers, Bucklersbury, London.

MARCH 31.

6232. **An improved process for electrically renovating, resurfacing and welding, fusing, or brazing strainer-plates used in paper-making, brewing, and other industries.** Henry John Rogers and John Paramor, Lavington, Watford, Hertfordshire.

6266. **Electromagnetic variable speed gearing.** William Worby Beaumont, 100, Palace-road, Tulse Hill, London.

6253. **Improvements in apparatus for propelling vehicles by electricity upon railways and tramways.** Alfred Spencer Churchill, 24, Southampton-buildings, London.

6259. **Improvements in the manufacture of filaments and other light-emitting bodies for electric glow lamps, and apparatus therefor.** Ernest Bailey, 191, Fleet-street, London.

APRIL 1.

6287. **Improvements in incandescent lamps.** Ernest Böhm, 42, Little Britain, London.

6288. **Improvements in or connected with the manufacture of alkalies, chlorine, and hydrogen by electrolysis.** Henry Clay Bull, 15, Water-street, Liverpool.

6289. **Improvements in the deposition of metals by electrolysis, and apparatus therefor.** John Cameron Graham, 13, Temple-street, Birmingham.

6293. **Improvements in motors and dynamos.** James Gibson, 33, North Hamilton-street, Kilmarnoch.

6312. **An electrical apparatus for starting gas engines and other prime movers.** Claude William Hill and Edgar Hughes, 5, Parsonage, Manchester.

6344. **Improved apparatus for straining or taking up slack in wires, cables, strips, or the like, more especially intended for straining electric conductors between their supports.** Clement Johnson Barley and Mark Feetham, 47, Lincoln's-inn-fields, London.

6345. **Improved electric hammer for dental and other purposes.** Henry Nehmer, 4, Grafton-street, Gower-street, London.

6313. **Improvements in receptacles for electric and other wires, gas piping, and the like.** Thomas George Hartland and James Evans, 46, Market-street, Manchester.

6348. **Improvements in electrical relays** Willoughby Statham Smith and William Puddicombe Granville, 24, Southampton-buildings, Chancery-lane, London.

6364. **Improvements in electric arc lamps.** Henry Harris Lake, 45, Southampton-buildings, London. (Henri Wilbrant, Belgium.)

APRIL 2.

6371. **A safety incandescent lamp globe suitable for danger buildings.** Charles Frewen Jenkin, Waltham Abbey, Essex.

6402. **Improvements in the means of preventing interference of electric currents used in tramways, telephones, etc.** George Forbes, 34, Great George-street, Westminster, London.

6405. **An improvement in secondary voltaic batteries.** David Urquhart and James Miln Small, 28, Southampton-buildings, Chancery-lane, London.

6406. **Magnetic rolling apparatus.** Francis Edward Elmore and Alexander Stanley Elmore, 28, Southampton-buildings, Chancery-lane, London.

6428 **Improvements in the manufacture of elements for electric or secondary batteries.** Emmanuel Hancock and Augustus John Marquand, 24, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1878.

3988. **Electric lighting, etc.** Fox. (Seventh edition.)

1882.

4548. **Transporting by electricity.** Jenkin. (Second edition.)

1890.

694. **Electric, etc., lamps.** Clegg. (Second edition.)

10741. **Electric glow lamps.** Siemens Bros. and Co., Limited. (Siemens and Halske.) (Second edition.)

1891.

3984. **Electric arc lamps.** Patin.
4669. **Generating electricity** Hirbec
4682. **Electrical supply systems.** De Ferranti.
4684. **Measuring and adjusting magnetic force.** Mayes.
6048. **Electric power apparatus** North.
6489. **Electric incandescent lamps.** Pryke.
6793. **Producing pyrotechnic, etc., effects by electricity.** Champion.
7850. **Telephone exchanges.** Horn. (Strowger.)
7858. **Electrical switches.** Snell and others.
7878. **Preventing ignition of gases in dynamos, etc.** Rowan and McWhirter.
7911. **Electric switch.** Grimston.
7912. **Electric capstan** Grimston.
7937. **Electric resistance devices.** Cox.
8153. **Electrically propelled cars.** Siemens Bros. and Co., Limited. (Siemens and Halske.)
12107. **Electric light, etc., fittings.** Dow.
19965. **Electric conductors.** Love.
21551. **Electric light projection.** Pitt. (Sautter, Harlé, and Co.)
22037. **Printing-telegraph receiving instruments.** Lake. (Wright.)

1892.

1313. **Electric motor cars.** Short.
1557. **Electromagnetic apparatus.** Threlfall.
2448. **Telegraphic relays.** Wentz.
2497. **Magneto-electric machines.** Hunt.
2724. **Electro-therapeutical apparatus.** Grimm.
2744. **Telephonic instruments.** Hoffmann.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{1}{4}$
— Pref.	—	$2\frac{1}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	$20\frac{1}{2}$
House-to-House	5	$5\frac{3}{4}$
Metropolitan Electric Supply	—	9
London Electric Supply	5	1
Swan United	$3\frac{1}{2}$	$4\frac{1}{4}$
St. James'	—	$8\frac{5}{8}$
National Telephone	5	$4\frac{1}{2}$
Electric Construction	10	$6\frac{1}{4}$
Westminster Electric	—	$6\frac{3}{4}$
Liverpool Electric Supply	5	$5\frac{1}{8}$
	3	3

NOTES.

Personal.—Mr. W. Gibson Carey, of the English Thomson-Houston Company, has gone over to the States on a business visit.

Buckingham.—The Buckingham Town Council have sanctioned an agreement with Mr. A. C. Rogers for lighting the Town Hall with electric light.

Visits to Works.—The students of the Institution of Civil Engineers paid a visit to the works of Messrs. Siemens Bros. and Co., at Charlton, yesterday afternoon.

Utilisation of Water Power.—Works are in progress near Fond du Lac, on the St. Louis river, for the utilisation of 100,000 h.p. and distribution by electricity.

The Lane Fox Case.— We understand that the solicitors of Mr. Lane Fox have given notice of appeal, and thus one more electrical patent case has to be fought out to the bitter end.

Dawlish.—At the last meeting of the Dawlish Local Board, Mr. Cann suggested that the Parade should be better lighted, and the subject was referred to the Lighting Committee.

Water Power in Italy.—The town of Grosetto, in Italy, is to have an installation of electric light at 2,000 volts, using a waterfall 2½ miles away. Messrs. Siemens and Halske will supply the plant.

Newcastle Trams.—A correspondent of the *Newcastle Daily Chronicle* suggests the use of the water company's reservoir at Fenham for supply of power to drive electric trams in Westgate, Newcastle-on-Tyne.

Personal.—Mr. Emile Garcke, formerly managing director of the Brush Electrical Engineering Company, Limited, has been appointed managing director of the Electric and General Investment Company, Limited.

Bridlington Quay.—At a meeting of the Bridlington Local Board held on the 5th inst., Mr. R. Railston Brown was appointed electrical engineer to the Board, to take charge of their installation of electric lighting plant.

The Electric Light in our Homes.—We note the *Irish Health Record* for April contains, amongst other interesting matter, the first of a series of articles under the above heading, by Mr. Angelo Fahie, M.I.E.E., of Dublin.

Bedford.—The Electric Light Committee of the Bedford Town Council were much pleased with their recent visit to Eastbourne, and will recommend the Corporation to take preliminary steps towards establishing the light in the town.

Electric Locomotive.—Messrs. Brown, Boveri, and Co., of Baden, Zurich, are constructing what will be the largest electric locomotive in the world. It is to develop 1,500 to 2,000 h.p. The trial run will take place this summer.

Ozone Inhaler.—At a recent congress in Berlin, Dr. Schütze showed an apparatus consisting of an ebonite tube, in which were two metallic points connecting to a high-tension source, for the convenient inhalation of ozone by patients for whom its treatment was prescribed.

Development of India.—Mr. Rembrey, solicitor, of Calcutta, has published a pamphlet on the development of India, setting forth a long list of appliances and processes that might be introduced by enterprising firms. Among these, electrical processes naturally bear a large part.

Electric and Cable Railways.—The following have been named of the Select Committee of the House of Lords to join with the Committee of the House of Commons on electric and cable railways: The Earl of Lauderdale, the Earl of Strafford, Viscount Barrington, Lord Thring, and Lord Kelvin.

Bournemouth. — On the recommendation of the General Purposes Committee, the Bournemouth Town Council have approached Prof. Kennedy with reference to obtaining his advice as to the acceptance of the tenders which have been received for lighting the pier, offices, and gardens by electricity.

Telephones in the North.—The National Telephone Company will shortly open an exchange in Morpeth, and connect that town with Newcastle and neighbouring towns, as well as all the principal towns in Lancashire, Yorkshire, and the Midlands districts. The message rate to Newcastle and other towns within 25 miles will be 3d.

Bern.—A project for the use of water power for the transmission of power to the Jura-Simplon Railway is before the railway company. Projects have been received from the Oerlikon Company, the Société pour l'Industrie Electrique, of Genf, Messrs. Lahmeyer, and Messrs. Schuckert. It is expected the Lahmeyer system will be adopted.

St. Pancras.—Prof. H. Robinson has, on behalf of the St. Pancras Vestry, given notice to the London County Council of intention to lay mains in Seymour-street, Drummond-street, Clarendon-square, and Hampden-street. The Council has already approved the manner of laying electric light mains adopted, and has sanctioned the works mentioned.

Clermont-Ferrand.—The gas company of Clermont-Ferrand has contracted with MM. Schneider and Co. for the supply of a central station of 280 kilowatts capacity on the Zipernowski system. Corliss engines will be used. The station will have three sets of 90-h.p. engines and dynamos to start with. Other sets will be added as the demand extends.

Cable to the East.—A Reuter's telegram from Shanghai says: "The negotiations which have been recently carried on between the Chinese Government and the Eastern Extension and Great Northern Telegraph Companies have now been brought to a successful termination, and an equitable arrangement has been arrived at which contemplates a reduction in the tariffs."

Paris Electric Tramway.—The new electric tramway running from Saint-Denis to the Madeleine in Paris was publicly tested last week. The run to and fro was accomplished satisfactorily from Place aux Gueldres to the barrier at St. Ouen. The service is carried on by the Compagnie des Tramways, Nord—and a second service is to be shortly organised from Saint-Denis to the barrier of La Chapelle.

Electric Launch. — The "Bonnie Southport," an electric launch, had her trial trip on Tuesday last week, and on that occasion gave very satisfactory results. This handsome boat was designed and moulded by Mr. W. S. Sargeant, electrical engineer and launch builder, Strand-on-the-Green, Chiswick. The accumulators used—19 plates each, capacity of 140 ampere-hours—were supplied by the Electrical Power Storage Company. The propeller is one of Mr. Sargeant's latest type, designed for high speed and for electrical power.

Darwen.—The consumption of gas at Darwen is increasing rapidly. It has lately been decided by the Town Council to double the storage capacity of the gas-holder at a cost of £5,000. The last addition to the storage was in 1876, and since then the consumption has risen 75 per cent., the storage remaining the same. The present addition to the lighting accommodation is not by any means too soon, and there would eviden

for the establishment of electric distributing stations without overcrowding the output of illuminating agencies.

Electric Cooking.—Mr. W. J. Hammer recently wrote to the *Pall Mall Gazette* claiming the electric cooking apparatus as exhibited at the Crystal Palace and elsewhere as the invention of Mr. Carpenter, and the exhibit, we notice, is now described as "Carpenter's System," so there does not seem to be any disposal to credit the invention of cookers made of "resistance wires laid in enamel of the same coefficient of expansion as the wire," to any other inventor.

Bacup.—At a recent meeting of the General Works Committee of the Bacup Town Council it was resolved that the terms offered by Mr. Shoolbred, consulting electrical engineer, Westminster, and electrical engineer to the Corporation of Bradford, etc., be accepted, and that he be retained for consultation and the preparing of a preliminary report as to the best means to be adopted in carrying out electric lighting within the borough, upon the terms and conditions contained in such letter. The minutes were adopted, and the appointment confirmed at last week's Town Council meeting.

West Country Telephones.—The Western Counties and South Wales Telephone Company are by degrees accomplishing their object of bringing their subscribers throughout the West Country into telephonic communication with each other. The latest important section of their scheme completed is that between Exeter and Newton, by which all the more important towns south of Exeter are brought into communication with the county town. This work has only just been completed, but the trial of the line is eminently satisfactory, and a large increase in the list of subscribers may be expected.

Police Telephones.—Under the guidance of Captain Paterson, of the Glasgow Fire Brigade, a number of notabilities from Aberdeen were shown over the Glasgow Fire Brigade stations, and, amongst other recent improvements, were shown an exceedingly ingenious system of police telephone sub-stations, patented by Captain Paterson. It is proposed to bring the matter before the Aberdeen Watching Committee, in order to secure the erection of four or five of these stations in the suburbs. A visit was afterwards paid to the northern fire station, and on an alarm being given the brigade turned out, fully equipped, in 13 seconds.

The Boat Race.—A great many connected with the electrical trades and professions were present at the universities' boat race on Saturday, owing to the prevalence of electric launches and the kindness of the companies owning them. The General Electric Traction Company had 150 visitors at their "Immisch" charging station at Mortlake, nearly opposite the winning-post, who enjoyed themselves, the lunch, the warm weather, and the sight of the boats sweeping round the curve, Oxford well in front. Woolhouse and Rawson had also several electric boats filled with spectators, and Mr. Sargeant's barge was well patronised by electrical visitors—altogether a great success.

Tewkesbury.—At the meeting of the Tewkesbury Town Council last week Mr. Jackson proposed that a committee be formed to consider the question of applying for a provisional order under the Electric Lighting Act, and suggested certain gentlemen to form the committee, excluding those who were directors or had pecuniary interest in the gas company. The members of the directorate and shareholders of the gas company and others resented this, and two of them claimed to be placed upon the committee, and said it was a gross insult to exclude them. Mr. Jackson considered that from their position they could not approach the question unbiassed. The motion to include the whole of the members of the Council upon the committee was eventually carried.

Reading.—At the meeting of the Reading Town Council last week, the minutes of the General Purposes Committee were approved. Amongst other matters it was stated that an elaborate report was received from the town clerk as to the proposed license to be granted to the Reading Electric Light Supply Company, containing reservations in favour of the Corporation of the right to supply electricity for lighting the public buildings and streets by means of the water power of the Corporation at Southcote Mill. It was resolved that subject to the draft license being finally settled in consultation with parliamentary agents, that the town clerk be authorised to forward a copy to Mr. Kite, the electric light company's solicitor, informing him that the Council would be prepared to give their consent to the proposed license.

Preston.—Messrs. Latimer Clark, Muirhead, and Co. are now busily engaged at Preston putting down the central station plant for the National Electric Supply Company. A suitable site has been acquired, and the power will be generated by means of 10 engines and dynamos and five boilers, sufficient for the supply of 50,000 8-c.p. lamps. The engines will be of the vertical type, coupled direct to Clark-Muirhead's Westminster dynamos. Lancashire multitubular boilers will be used. The three-wire system, at 200 volts, will be used for distributing, the mains being laid in shallow iron culverts under the footpath. The station will be ready for supply in August, and the price charged will be 8d. per unit. The Preston Corporation have entered into a contract to take the lighting of the whole of Fishergate, the principal thoroughfare, and other streets will doubtless be lighted in the same way.

Bradford Reduces the Rate.—We are extremely pleased to see that at the meeting of the Bradford Town Council on Tuesday, on the recommendation of the Gas and Electricity Supply Committee, it was decided to reduce the price charged for electricity from 6d. to 5d. per unit as from the 1st inst. Having gone rapidly forward from making a slight loss to making a considerable profit over expenditure, Bradford has seen its way to reduce still further its already cheap rate for electric lighting. Taking all outgoings into consideration, this price of 5d. per unit will mean that the actual "sheer cost of manufacture" is only about half this, say 2½d. per unit. Bradford has now the satisfaction of having one of the most economical stations and the lowest rate of charge in the kingdom, and bears out abundantly our contention, that the best policy of a corporation is to own their central electric station.

Coventry.—At the meeting of the Coventry City Council on Tuesday, the Mayor presented a report from the Electric Light Committee, recommending the high-tension system for adoption in Coventry. The advantages which decided the committee in the recommendation of this system were that the generating station might be placed in any part of the city or suburbs; there would be a great saving in the first cost on account of the smaller mains required, and should a refuse destructor be erected the two might be placed side by side, and the heat from the destructor used as part of that required in the boilers of the generating machinery. He added that before long they would be in a position to give the inhabitants a good light, which would certainly be very advantageous in many departments of trade. He moved the adoption of the report, which was seconded by Mr. Thomas, and after a long discussion adopted.

Bradford Electric Cars.—A very successful trial trip was made with Mr. Holroyd Smith's electric car at

Bradford on Tuesday. Since the preliminary trial the overhead wires have been altered at the curve, and the car rounded the turn with ease. Three trials were made, the ascent and descent to Manor Row being made with ease and safety. The method of taking off the current has been modified, the cross-bar used at first has been changed to the trolley pole with grooved pulley, making better contact. The trials were witnessed by several members of the Tramways Committee and Mr. J. H. Cox, the borough surveyor, and gave general satisfaction. In one of the trials over 30 persons rode in the car, and there was no diminution of speed compared with that when a lighter car went up the incline. The motive power was about 300 volts. It is expected that at an early date Major-General Hutchinson, of the Board of Trade, will come down and inspect the line.

Exeter.—At the Exeter City Council Mr. Perry is to move: "That in view of the Exeter Electric Lighting Company placing the whole of their wires underground, the time has now arrived for the reconsideration of the question of lighting the main streets with electricity, and that the surveyor be instructed to prepare a report as follows: 1. Giving the present annual cost of lighting the streets within the area set out in the second schedule to the Exeter Electric Lighting Company's provisional order. 2. To prepare a plan showing the number and power of electric lamps required for the same area. 3. To prepare an estimate of the first cost of lighting. 4. To obtain from the Exeter Electric Lighting Company an estimate of the cost per annum for the supply of light as per plan. 5. Any other information that may assist the Council in coming to a decision." The Exeter Electric Light Company have already given the Council a month's notice of their intention to place their wires underground.

Nottingham.—The specially appointed Electric Lighting Committee of the Nottingham Town Council have decided, understands the *Nottingham Daily Express*, to commence an installation for lighting by electricity within a prescribed area, which includes the Market-place and surrounding thoroughfares. A competent electrical engineer has been advertised for in order to advise upon and carry out works necessary. After visits paid to Newcastle, London, Sheffield, and elsewhere, the various systems which obtain have been discussed and considered. The result of these deliberations shows that within a limited area, the system most favoured is the low-tension system This is regarded as being suitable for any area not exceeding a radius of more than one mile from the central distributing station. For long-distance transmission experts advise the high-tension system. It is thought that under present known conditions (allowing for the present low price of gas in Nottingham) the cost of electric lighting would be about double that of illumination by gas.

The Lauffen-Frankfort Transmission.—Dr. Julius Maier writes on Wednesday to the *Times* that he had received the following telegram from Mr. Sonnemann, the president of the late Frankfort Exhibition: "Official report of testing committee gives mean efficiency in Frankfort at full load 74 per cent., where loss of energy in dynamo, 8 to 10 per cent., included; from this results for transmission proper to secondary transformer at the exhibition a mean efficiency of from 80 to 82 per cent." It is gratifying to note that the minute investigations of the testing committee bear out the statement of the *Times* correspondent, who from his personal investigations gave the efficiency as not less than 75 per cent. "The result obtained in the Lauffen-Frankfort experiment," adds Dr. Maier, "is magnificent. It surpasses even the most sanguine expectations, and removes any doubt, if doubt still existed, as to the practical feasibility of electric power transmission over a long distance. It is impossible to foresee the far-reaching consequences of this experiment; it is destined to revolutionise all our industrial methods, and to lead to a general utilisation of natural forces now running to waste."

Electrical Measurement.—An interesting paper on "The Measurement of Electricity," was delivered before a recent meeting of the Dumbarton Philosophical Society by Mr. Malcolm Sutherland, head of the electrical staff in Messrs. William Denny and Bros., of Leven Shipyard. He explained, with the aid of specimen apparatus, the nature of electrolysis and the method of standardising for calibrating the various instruments employed in electrical measurement. The latter were described under three classes—viz., those controlled by gravity, by elasticity, and by magnetism. Amongst the instruments most fully described were the Siemens dynamometer and the Thomson mirror and graded galvanometer. Voltmeters, both current and electrostatic, were then described, and the paper wound up with an elaborate description of the ordinary electric meter in its various forms now in use for measuring the quantity of electrical energy used during any given time. The author affirmed that, in spite of the multiplicity of meters already brought out and of patents applied for, there was still a decided want for a really good simple and cheap meter, and that a fortune awaited the inventor of an article meeting these requirements.

Copper Mains.—A handy pocket table, for which we have been looking for some time, has been sent to us by Messrs. Fowler and Lancaster, being "Curves, Tables, and Simple Rules relating to Copper Conductors," by E. W. Lancaster (price 1s.). It consists of a sheet folded in four, and pasted on a stiff back. The first page is a table of particulars, giving current-carrying capacity at 1,000 and 800 amperes per square inch, pounds per yard, yards per pound, diameter, resistance, and yards per ohm. The third and fourth pages give curves; in the first place, "curves showing gauge of conductor required to carry a given current, the fall of potential per 100 yards being specified"; and in the second place, "curves showing gauge of conductor of given length required to carry a given current at a fall of potential of one volt." Page 2 gives examples of calculations. By these curves and tables the cable to carry a given number of lamps at given fall of potential to a given distance can easily be worked out. Long-distance transmission conductors can also be calculated, and problems as regards current density for given conditions. It is seldom we see such useful material in such a compact and convenient form at so cheap a price.

Huddersfield.—An enquiry was held at Huddersfield last week by Mr. R. Walton, M.I.C.E., relative to an application by the Huddersfield County Council for sanction to borrow £50,000 for electric lighting purposes. The town clerk (Mr. H. Barber) stated that on the 6th April last year the County Council applied to the Local Government Board for sanction to borrow. The Board of Trade issued two electric lighting orders for the borough in 1890, the second in August of that year, and by that order it was provided that the Council should commence the works in the compulsory area within two years of that date. The area of supply is the whole of the borough, with the exception of one portion, which was added after the order was made—namely, the extensive district of Longwood. Mr. A. B. Mountain, the electrical engineer, produced plans of the generating station, which will be in St. Andrew's-road. There would be provision for 6,660 eight-candle light incandescent lamps. Ther-

Brush Company's make. There was no opposition to the project. On the proposal of the Mayor, seconded by the ex-Mayor, the inspector was thanked; and, in reply, he said that as the matter was of an urgent nature he should do his best to expedite matters. It is understood that the Corporation have made arrangements to lease some land in St. Andrew's-road for 999 years at a yearly rental.

Crompton-Howell Accumulators.—"The outcome of eight years' continuous thought and study,' says the catalogue of the Crompton-Howell Electric Storage Company, "the cells have now attained such a high state of efficiency that they are being largely adopted in England and other parts of the world, and since this perfection of manufacture has been reached, no single instance of breakdown or injury to the cells has occurred." The process invented by Mr. Howell is of producing lead plates from blocks which are cast at a temperature when the lead is just at the point of crystallisation, resulting in blocks of "lead sponge," which are sawn up into plates and formed. After five or six years' working these plates appear to remain in as good a condition as when first put to work, and can be submitted to very rough usage without deterioration. They are more particularly useful for large sets, such as for central station lighting, for which purpose at Kensington and elsewhere they have had a long trial. The maintenance, it is stated, has only cost the users from 1 to 5 per cent., and the company will undertake maintenance contracts at rates, varying according to circumstances, from 5 per cent. and upwards per annum. The watt efficiency, according to Prof. Kennedy, is 86·5 per cent., and the ampere efficiency 95 to 96 per cent., and these results are calculated from the switchboard terminals—that is, including the connecting resistances. The catalogue contains illustrations of the cells and a number of testimonials and reports, besides reference to users and full lists of prices. It is evidently a catalogue that every electric lighting engineer should have at his side for reference.

Glasgow. — At the meeting of the Glasgow Town Council on 7th inst. the minutes of the Electric Lighting Committee were discussed. The report stated that the meeting of the Sub-Committee on Electric Lighting held on 30th March, agreed to recommend that after 31st May next the charge for electricity supplied be at the rate of 7d. per unit net to all customers. There was submitted and read a letter, dated 26th ult., from the Secretary of the Board of Trade, intimating that the Board propose to limit their approval of the high-pressure system of supply of electricity by aerial wires to one year from that date. At a meeting of the Sub-Committee on Contracts held on 5th inst., the sub-committee resolved to recommend acceptance of the offer, dated 4th April, by Messrs. Latimer Clark, Muirhead, and Co., provided satisfactory detailed drawings are submitted to the Corporation. Bailie J. H. Martin asked whether it would not have been possible for the committee to have taken separate contracts for the engines, dynamos, and wires. It was peculiar that in the city of Glasgow, where there was so much engineering skill, they should have to go to London for engines for the electric work. Mr. Ure said that the amount of the contract was £12,900, and the next offer, which was by Messrs. Mavor and Coulson, was £500 higher, and the others ranged up to £18,000. As to dividing the contracts, they had done so as far as was possible, but they felt they ought to have one responsible firm. With regard to the "engines," Mr. Ure is reported to have said—though we suppose he means dynamos—Messrs. Latimer Clark, Muirhead, and Co. were most successful makers. Not much machinery for electric lighting had been made in Glasgow. At the meeting on Monday the Corporation decided to light the streets by means of 106 arc lamps at £20, being £2,120, to which must be added a capital outlay of £2,500 for fittings, making the annual cost £2,371. The extended gas would cost £1,627, so that there is an addition of about £740 a year for about ten times the light.

Blackpool.—The minutes of the Blackpool Electric Lighting Committee presented at last week's Town Council meeting, were as follows: "Resolved, that the chairman (Councillor Pearson) and the town clerk be desired on behalf of this committee, to confer with the Markets and Gas Committee in reference to this committee obtaining tests of the electric lighting on the Promenade, and also as to how far the present electric lighting on the Promenade can be made available in further lighting of the borough by electricity; also that a circular be issued to the public for the purpose of ascertaining the public requirements for electric lighting in Blackpool." In discussing these minutes, the Mayor suggested that Mr. Councillor Pearson should inform the Council of the progress the committee had made in their investigations. Mr. Councillor Pearson said he was sorry that the report of their investigations could not be submitted to that meeting. The report, as a matter of fact, had been ready for some time, but it had seemed to the committee that it would be purposeless to submit the report to the Council unless accompanied by some recommendation. The committee had not been idle, and inasmuch as the matter was full of difficulties, he hoped that the Council would see its way to support the committee when they did submit their report. The committee was only appointed on December 1, and since then most exhaustive investigations had been made. The full committee met two or three times a week to interview some of the most important electrical engineers in the country. He hoped that by the next Council meeting the committee would be prepared with their report and recommendations, with an estimate for the scheme to be submitted for approval. The matter was an important one, and a large amount of money would be asked for to carry out the work. In the meantime, he assured them that the members of the committee were doing everything in their power to push on the scheme, and they did not intend to waste a day unnecessarily. The minutes were then passed.

Electric Fog Annihilator.—Everyone who has witnessed the experiments which Mr. J. W. Swan is fond of showing to visitors to Bromley—the smoke deposition experiments of Dr. Oliver Lodge—must have inevitably had the idea that possibly some actual use might eventually be made of electricity for dispersing fogs. The following note from the *Philadelphia Ledger*, if a little "tall," bears promise of some actual utility in this direction: "An inventor, who claims to have an invention which will overcome fog, is now in New York perfecting details of his remarkable discovery. Experiments which have been secretly made at Sandy Hook and in Boston Harbour are said to have been successful. The business man of the fog annihilator is M. E. Johnson, a capitalist, whose home is in Pittsburg. 'The force used,' Mr. Johnson says, 'is a form of electrical discharge. The effect is in direct ratio to the intensity of the fog—that is, the denser the fog the more easily it is affected by the discharge. The consequence is that with a dense fog a larger area can be cleared with the release of the same amount of energy. There is no electric spark to be seen, and no detonation or explosion accompanies the discharge. The largest area we have been able to practically clear by one discharge has been 70,500 square feet, nearly two acres, which is approximately 150ft. in every direction from the site of the discharge. This was done in Boston Harbour. With

greater energy, such as will readily be obtainable on ocean steamships, many times that area can be cleared. The fog falls in the form of rain. The atmosphere of the cleared area is exceedingly clear, just the same as it is after a rain in summer. The period of absolute absence from fog is merely momentary in duration. The fog immediately begins to form and to drift in from surrounding areas. This takes place so rapidly that within five minutes the original condition prevails. In our experiments in Boston Harbour seven minutes elapsed before the fog re-formed. It is, of course, impossible to obliterate the fog, but by a succession of discharges at intervals of two minutes it keeps the area I have referred to practically clear.' In conclusion Mr. Johnson said: 'We did not wish to apply for patents until we were sure the fog-destroyer would be successful. Now there can be no doubt as to its efficiency. Before long the apparatus will be a part of the equipment of the transatlantic liners.'"

Burton.—At the monthly meeting of the Burton Town Council, held on the 6th inst., the Gas and Electric Light Committee presented their report, which dealt chiefly with a recommendation for the acceptance of the joint tender of Messrs. John Fowler and Co., of Leeds, and Messrs. Hammond and Co., of London, for the plant (exclusive of building) for the installation of the electric light into the borough, subject to the approval of the Board of Trade. Alderman Lowe moved the adoption of the report, and said, with regard to the electric lighting, the committee believed they were putting the work into the hands of two good firms, who would carry it out in an efficient and satisfactory manner. When advertising for tenders they instructed the gas works manager to prepare specifications and conditions on a broad basis, so as to leave the system of installation entirely for the tenderers to suggest the one which they thought most suitable for the requirements of the town. The result was that they received 16 tenders, 13 being on the high-tension alternating-current transformer system, and the remainder on the continuous-current system, with transformer substations and storage batteries. One of the firms who tendered for the latter admitted that it would be impossible to adopt the continuous system at Burton except at an enormous figure. After very careful enquiry they had come to the conclusion that that was a perfectly accurate statement, and they had agreed to adopt the high-tension alternating-current transformer system. The tenders were reduced to two, and those they now recommended were unanimously selected. The committee had throughout been guided by a desire solely of getting the very best system and firm, and they recommended both for the acceptance of the Council with every confidence. In the course of their enquiries they were informed without exception that the cost of electricity as compared with gas for an illuminant was high, so that they had no reason to fear that the gas works were likely to suffer by its introduction into the town; as it was believed that for many years to come, at any rate, electricity would be used as a lighting agent by only those who could afford to pay for the luxury. Councillor Graham seconded, but took a more hopeful view than Alderman Lowe as to the popularity of the electric light, and predicted that 40 years hence gas would be as old fashioned as oil lamps are now. He had hoped that they would have been able to use the water power of the town, and so reduced the working expenses. After some further discussion as to the effect of electricity upon the price of gas, the report was adopted.

Swinburne High-Tension Apparatus.—We have received from Messrs. Swinburne and Co. an invitation to visit experiments with their 130,000-volt transformers at the Crystal Palace, for the evening of Wednesday. As our day for going to press, owing to the holidays, falls on that evening, we cannot describe the actual experiments carried out, but we give the following interesting description of the behaviour of the apparatus which Messrs. Swinburne have been kind enough themselves to furnish: "The subject of high pressures, or 'tensions,' and their practicability for transmission of power to long distances is rapidly coming to the front, and it is therefore becoming a matter of serious importance to ascertain the phenomena of high-tension currents, and especially the insulating powers of different subjects under these high pressures. In view of this fact, and also of the fact that we are now being required to make 30,000 and 40,000 volt transformers for some of the large cable companies to test their cables with, we decided to try and construct a transformer to give an enormously higher pressure than any hitherto attempted. The result has exceeded our most sanguine anticipations, and we show at the Crystal Palace a transformer taking 50 h.p. and giving 130,000 volts—a pressure nearly three times higher than that obtained in the transformer which created such a sensation at the Frankfort Exhibition last year, and now being shown in another part of this building. We do not think we have by any means reached the limit of possible pressures which may be employed. In fact, we believe this present transformer could be safely run up to at least 160,000 and possibly 200,000 volts. In order to better realise what this enormous pressure means, we would point out that by using our transformer at its full power we could transmit 50 h.p.—that is to say, sufficient power to drive a large factory through a wire no thicker than a hair. The following are some of the more striking experiments which illustrate the properties of these enormous pressures. When the electrodes connected with the transformer are brought within some 6in. a discharge takes place with some noise, and a snake-like arc remains between them. The electrodes can now be separated some feet before the arc ceases. The arc twists and writhes about owing to the mutual repulsion of its successive portions. The insulating power of anything is merely a matter of degree, and many substances which are considered perfect insulators for all ordinary pressures become nothing more or less than conductors at these high voltages. Slate is generally considered a first-class insulator. With 100,000 volts, however, it may be considered a conductor, and can be used in place of carbon to form the electrodes in an arc lamp; or a bar of it may be used to carry current as if it were a copper rod. One of the most curious experiments consists in subjecting a yard or so of deal board to the high pressure. Small sparks seems to run about erratically in the interior of the wood, and at last the circuit is completed by the charred wood. An arc is then formed, which leaves the wood and wriggles about in the air above it with a roaring sound. Beautiful effects are also produced by passing the arc through blocks of table salt or marble. The most striking experiment, the electric octopus, is produced by placing a large pane of glass between the electrodes. There is a crackling discharge all over the glass. This must be seen, as it cannot be described. The glass is eventually pierced, and the hole is immediately melted up again by the intense heat. Apart from experimental interest, these high pressures show what can be done. At 130,000 volts it is possible to pass a small current through a man, and to transform it down and run a 2-h.p. motor. This experiment, however, is not performed. With a pressure of 130,000 volts the transformer could work a 50-h.p. motor placed in America through a wire a tenth of an inch diameter with a loss of only 2 h.p. on the way."

LIST OF DETAILS OF DIRECT-CURRENT DYNAMOS AT THE CRYSTAL PALACE, 1892.

Maker, or name of exhibitor.	Normal.			Output in kilowatts at		Type.		Number of poles.
	Volts.	Amperes	Speed	normal speed.	wh'n circ'mfer'ntial spe'd of core = 2,000ft. per min.	of field magnets.	of armature.	
The Brush Company	65	185	285	12	—	Victoria Brush	Disc	4
,, ,,	100	360	550	36	—	Two double horseshoe	,,	4
,, ,,	3,000	10	800	30	—	Double ,,	Open circuit	2
Crompton and Co.	225	600	350	130	101	Two single ,,†	Drum	4
,, ,,	225	500	350	112	123	Double ,,	,,	2
,, ,,	1,450	25	800	36	18·2	,, ,,	Ring	2
,, ,,	110	500	890	55	—	,, ,,	Drum	2
Easton and Anderson	100	150	350	15	28·2	Manchester type	,,	2
,, ,,	100	150	800	15	15·5	,, ,,	,,	2
Ernest Scott and Mountain	105	52	1,050	5·5	3·5	Inverted single horseshoe	Disc	2
The Electrical Construction Corporation	110	240	600	26	24	,, ,, ,,	Drum	2
,, ,, ,, {	110	370	500	40	70	,, ,, ,,†	,,	2
,, ,, ,, {	1,000	—	—	40	—	—	—	—
Goolden and Co.	115	142	850	16	10	,, ,, ,,	Drum	2
The Gulcher Company	65	600	750	40	17·1	Double horseshoe	Disc	4
J. H. Holmes and Co.	65	150	250	10	23	Upright single horseshoe	Ring	2
Johnson and Phillips	210	620	130	130	160	Eight-pole internal type†	Drum	8
,, ,, ,,	140	100	700	14	14	Inverted single horseshoe	,,	2
,, ,, ,,	600	30	900	8	6	Four-pole internal type	,,	4
,, ,, ,,	105	62	950	6·5	6	Inverted single horseshoe	Ring	2
Laurence, Scott, and Co.	50	130	320	6·5	12·5	Four-pole internal	Drum	4
,, ,, ,,	100	110	700	11	14	Inverted single horseshoe	,,	2
Laing, Wharton, and Down	110	300	900	33	—	Four-pole internal	—	4
The Newton Electrical Engineering Company	80	200	350	16	27	Upright single horseshoe	Ring	2
The Roper Electrical Engineering Company	65	175	750	11	10	Inverted ,, ,,	,,	2
Ronald Scott and Co.	80	165	280	13	28·5	Upright ,, ,,	Drum	2
Siemens Bros. and Co.	120	1,500	350	180	165	,, ,, ,,	,,	2
,, ,, ,,	106	220	200	23	63	,, ,, ,,	,,	2
,, ,, ,,	120	200	320	24	38	,, ,, ,,	,,	2
,, ,, ,,	120	400	450	48	51	,, ,, ,,	,,	2

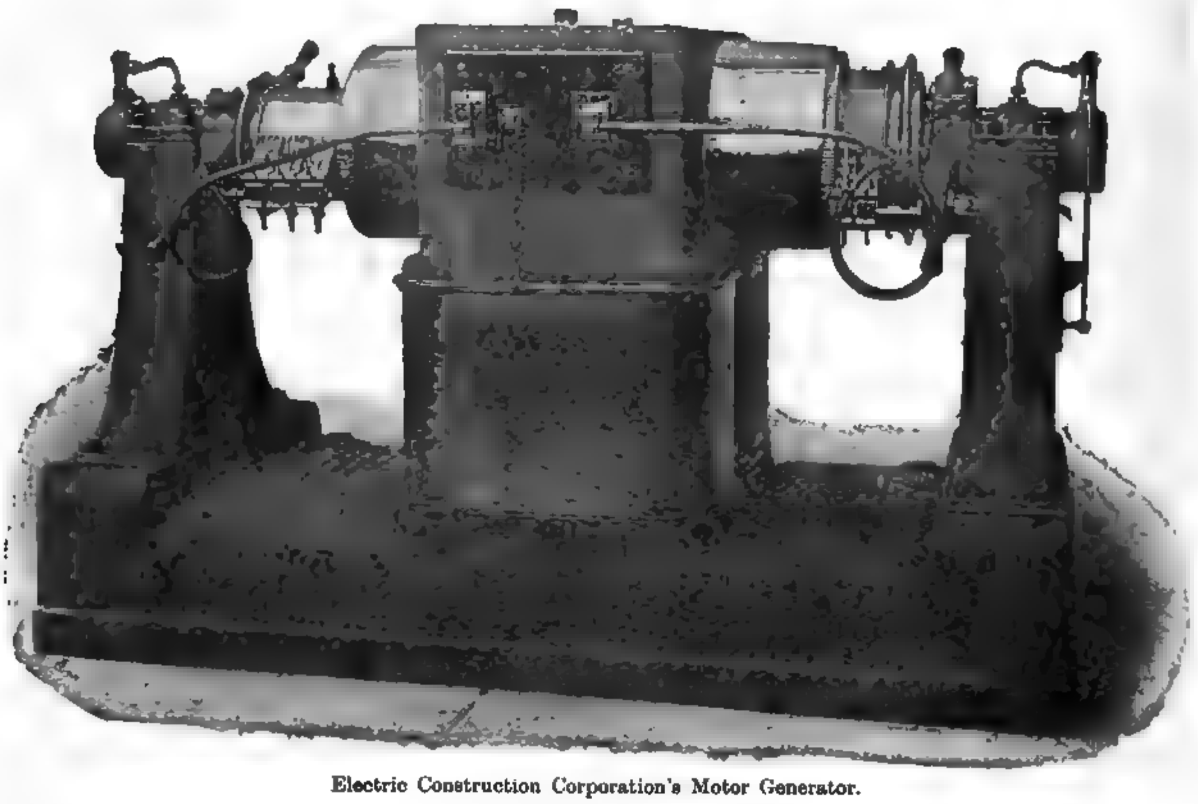
† *See* illustration

THE CRYSTAL PALACE EXHIBITION.

DIRECT-CURRENT DYNAMOS.—IV.

BY R. W. WEEKES, WHIT.SCH.

The motor-generator made by the Electric Construction Corporation has many points worthy of consideration, and as it cannot be classed with the dynamos it will be well to consider its construction first. This machine is accurately described by its name, and is essentially a distinct motor and dynamo working in a common field. The armature core is built up as shown in Fig. 13, except that there are two channels at each end to carry the connections. Then two distinct sets of wires are wound on, one of 648 turns of fine wire, and the other of 72 turns of thick conductor, counting all round the circumference. The ratio of the turns is 1,000 to 111, allowing nearly 1 per cent. for loss in the armature resistance. The fine wire forms the motor circuit, the high-tension current supplied to it driving the armature, and the other conductors act as

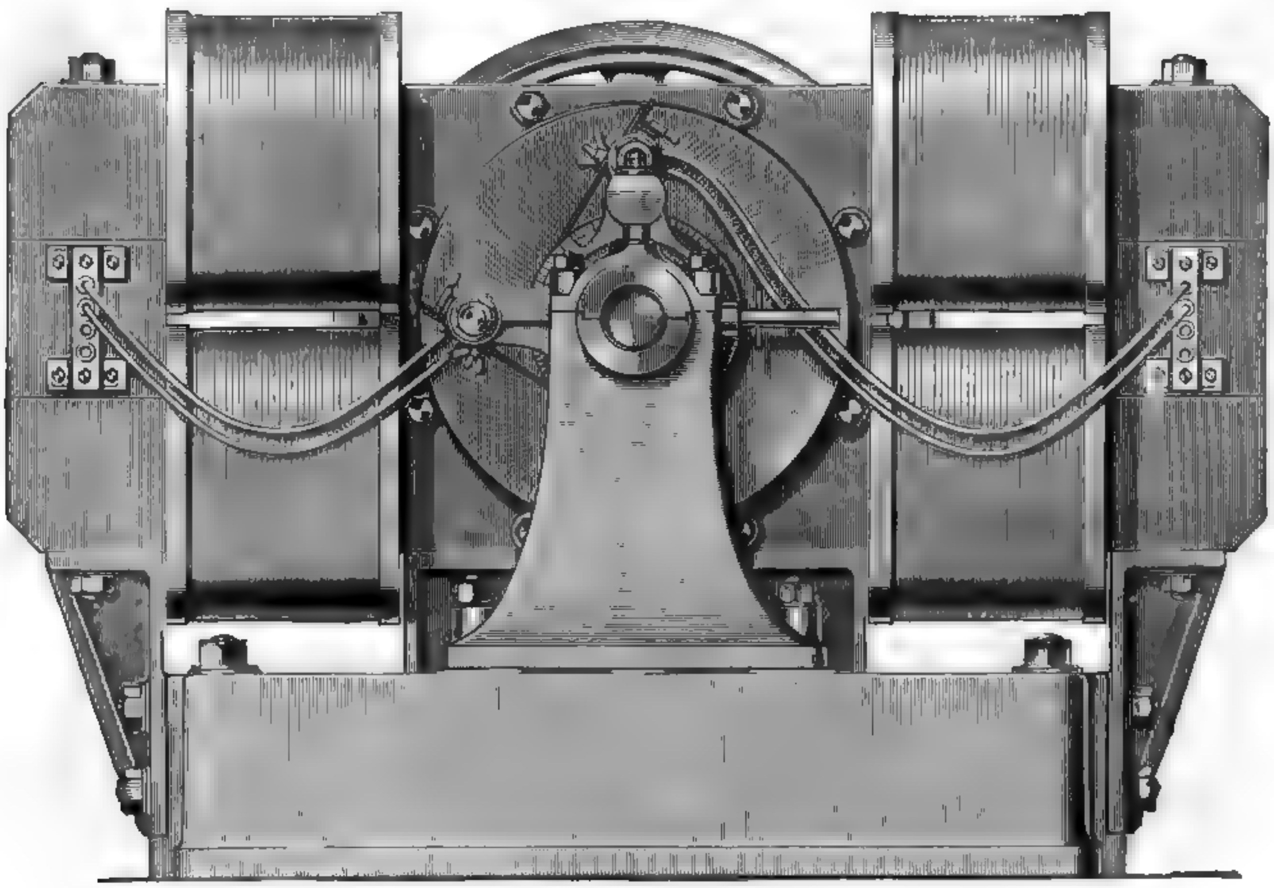


Electric Construction Corporation's Motor Generator.

LIST OF DETAILS OF DIRECT-CURRENT DYNAMOS AT THE CRYSTAL PALACE, 1892.

Weight in tons.		Floor space.		Kilowatts per ton at 2,000ft. circumferential speed.	Kilowatts per square foot of floor space at 2,000ft. circumferential speed.	Armature.					
						Core.			Conductor.		
Belt driven	As supplied for coupling direct.	Belt driven.	Direct driven.			Diam. inches.	Length in inches	Depth in inches	Number of turns.	Section of conductor.	Description.
		ft. in. ft. in.	ft. in. ft. in.								
—	—	—	4 6 × 2 8	—	—	—	—	—	—	—	—
—	—	4 9 × 2 8	—	—	—	—	—	—	—	—	—
—	—	6 8 × 2 8	—	—	—	—	—	—	—	—	—
—	5	—	4 6 × 7 6	20	3·01	28	16	—	[illegible]	—	Crompton bars
—	—	—	—	—	—	20	36	—	128	—	"
1·65	—	3 3 × 5 0	—	11	1·11	20	5	3½	—	—	Round.
3·25	—	—	—	—	—	—	—	—	—	—	Crompton bars.
—	1·5	—	5 0 × 2 10	18·8	2·01	11¾	20	—	178	—	Laminated strip
0·5	—	4 0 × 2 2	—	31	1·78	9¾	10	—	120	—	Rectangular
—	—	3 0 × 2 4	—	—	0·5	12	4½	—	—	—	Round
2·3	—	5 8 × 2 0	—	10·5	2·14	14	14	4½	[illegible]	·05 sq. in.	Rectangular
{ 6·1	—	7 0 × 3 3	—	11·5	3·09	18	20	6	72	·075 sq. in.	"
{ —	—	—	—	—	—	—	—	—	324	·0113 sq. in.	—
—	—	4 3 × 2 0	—	—	1·18	10½	[illegible]	—	—	—	—
—	—	6 6 × 2 9	—	—	[illegible]	24	5	5¼	160	—	Rectangular
—	1·15	—	2 8 × 2 3	20	3·83	13½	11¾	2¾	272	—	Laminated strip
—	10	—	5 3 × 6 9	[illegible]	4·52	48	18	3½	362	—	Crompton bars
1·5	—	3 8 × 2 0	—	9·4	1·91	11	[illegible]	2¾	162	3(·270 × ·035)	Laminated strip
—	—	3 6 × 2 8	—	—	0·65	11	11	2¾	102	—	—
0·62	—	2 8 × 1 6	—	9·7	1·51	9	9	1¾	[illegible]	(·170 × ·105)	—
—	1·0	—	2 8 × 2 6	12·5	1·88	12½	[illegible]	—	—	—	—
0·6	—	3 3 × 2 0	—	23	2·15	8½	7½	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	4 6 × 2 6	—	2·40	13	16½	—	—	—	—
1·25	—	3 3 × 2 4	—	8	1·31	11	9	—	[illegible]	—	—
—	1·75	—	4 3 × 2 0	16·2	3·65	11½	18	—	[illegible]	—	Laminated strip
—	13·6	—	6 9 × 6 0	12·2	4·08	24	34	—	—	—	Crompton bar
—	2·9	—	4 6 × 2 10	22	[illegible]	[illegible]	20	—	—	—	—
—	2·8	—	4 0 × 2 10	13·6	3·40	15	19	—	—	—	—
—	3·2	—	4 3 × 4 0	16	3·01	16	20	—	—	—	Crompton bar

in an ordinary dynamo. The field magnets have two sets of coils on them—one a series winding in the high-tension undue rush of current, is at the central station. The armature running in a weak field soon attains a higher speed



Crompton and Co.'s Dynamo.

circuit, and the other a shunt to the low-tension circuit. When starting, the lamp circuit is broken and the machine is started as a series motor. The rheostat, to prevent an than required, but as soon as the secondary excites, the field is strengthened by the shunt coils and the working speed is obtained. The load is then switched on from the central

LIST OF DETAILS OF DIRECT-CURRENT DYNAMOS AT THE CRYSTAL PALACE, 1892.

Maker, or name of exhibitor.	Commutator.					Field magnets.		Magnetisation in C.G.S. lines per square centimetre.			Remarks.
	Number of segments.	Material.	Brushes.			Section of bars.	—	Total lines from one pair of poles.	Induction in the armature $\mathfrak{B}a$.	Useful ind'ct'n in the m'gn'ts $\mathfrak{B}m$.	
			Number.	Size.	Material.	l'gth. thickness.					
				in. in.		in. in.					
Brush Co.	—	Copper	2	$1\frac{5}{8} \times \frac{1}{4}$	Copper gauze	—	W.I.*	—	—	—	—
,, ...	—	,,	2	$2 \times \frac{1}{4}$	,,	—	,,	—	—	—	—
,, ...	—	,,	—	—	Copper plates	—	,,	—	—	—	A.
Crompton and Co..	107	Cast copper	3	$2 \times \frac{3}{8}$	,,	14 × 12	W.I.	9,400,000	12,500	8,700	—
,,	64	,,	—	—	—	6 bars 6×6	,,	31,500,000	13,000	11,200	—
,,	90	,,	2	$1\frac{1}{2} \times \frac{3}{8}$	Copper plates	$7\frac{1}{2} \times 4$	,,	—	—	—	B.
,,	—	—	—	—	—	—	—	—	—	—	—
Easton & Anderson	89	Drawn copper	3	$2 \times \frac{3}{8}$	Copper gauze	—	W.I.*	9,910,000	—	—	C.
,,	60	,,	3	$1\frac{1}{2} \times \frac{3}{8}$	,,	—	,,	6,450,000	—	—	C.
Scott and Mountain	—	,,	2	$1\frac{1}{2} \times \frac{3}{16}$	Brass gauze	—	,,	—	—	—	—
Elec. Con. Corpn..	60	Cast copper	3	$2 \times \frac{3}{16}$	Copper gauze	14 × 7	W.I.	9,500,000	15,000	—	—
,,	{ 36	,,	3	$2 \times \frac{3}{8}$	,,	20 × 12	,,	19,000,000	15,000	12,400	} D.
,,	{ 162	,,	—	—	—	—	—	—	—	—	
Goolden and Co. ..	—	,,	2	$2 \times \frac{1}{4}$	Copper gauze	—	W.I.	—	—	—	—
Gulcher Co.	80	Brass	2	$2 \times \frac{1}{4}$	Brass gauze	circular bars	W.I.*	17,100,000	12,700	—	—
J. H. Holmes & Co.	74	Drawn copper	—	—	Copper gauze	10 dia.	,,	6,000,000	16,300	11,800	—
Johnson & Phillips.	181	,,	4	$1\frac{3}{4} \times \frac{11}{16}$	Brass gauze	16 dia.	C.I.*	7,000,000	10,600	5,400	—
,,	81	,,	2	—	,,	$15 \times 5\frac{3}{4}$	W.I.	7,600,000	15,300	13,800	—
,,	51	,,	1	$1\frac{3}{4} \times \frac{3}{16}$	,,	$10\frac{1}{4} \times 5$	C.I.	2,040,000	—	6,100	E.
,,	57	,,	2	$1 \times \frac{1}{4}$	,,	$8\frac{1}{2} \times 5$	W.I.	3,000,000	16,400	11,300	—
Laurence-Scott ...	—	Cast copper	2	$1\frac{1}{4} \times \frac{1}{4}$	Copper gauze	—	C.I.	—	—	—	C.
,,	60	,,	—	—	,,	—	W.I.*	—	—	—	C.
Laing-Wharton ...	—	—	—	—	—	—	—	—	—	—	—
Newton Eng. Co...	—	—	2	—	Copper gauze	$15\frac{1}{4} \times 7$	W.I.	—	—	—	—
Roper Eng. Co......	72	Cast copper	3	$1\frac{1}{2} \times \frac{1}{4}$	,,	9 × 9	C.I.	3,700,000	—	7,100	—
Ronald Scott & Co.	96	Cast phosphor bronze	2	$2 \times \frac{3}{16}$	Brass gauze	19 × 7	W.I.	9,250,000	—	10,800	—
Siemens Bros.	—	—	3	$4 (2 \times \frac{1}{4})$	Copper gauze	$34 \times 16\frac{1}{2}$	,,	—	—	—	—
,, ...	—	—	—	—	Copper wire	—	—	—	—	—	—
,, ...	Messr	s. Siemens Bros. an	d Co.	do not w	ish their elec	trical details	publi	shed.	—	—	—
,, ...	—	—	—	—	Copper wire	$19 \times 9\frac{1}{2}$	W.I.	—	—	—	—

A. Brush open-coil arc lighting dynamo. B. Arc lighting dynamo, constant current. C. Armature with toothed core. D. Motor-generator. E. Arc lighting dynamo. * With cast-iron pole-pieces.

station by means of an electromagnet in the pilot wire circuit. The series winding regulates the P.D. in these mains, acting like the compound winding in a motor.

This machine has many peculiar advantages, and is not subject to some of the disadvantages of large two-pole dynamos. The resultant armature reaction is practically nil, as the current volume in the motor circuit is only slightly in excess of that in the generator circuit, and acts in the opposite direction. This effects three radical improvements:

1. The lead to the brushes does not vary with the load;
2. The field is not weakened by the armature current;
3. The field is not distorted, and hence the Foucault-current loss in the conductors is constant, and does not increase as the load increases.

The fact that the motor armature conductors drive the generating wire was mentioned and explained last week. The efficiency claimed for this machine is high, being 87 per cent. at half load, and 92 per cent. at full load. It is interesting to note the similarities of this machine and an alternating-current transformer. The armature of the motor-generator will act as an alternating-current transformer, and the distinctive difference between the two is that in the direct-current transformers the fluctuation of induction is produced by movement of the iron, and that the currents are commutated to make their directions constant.

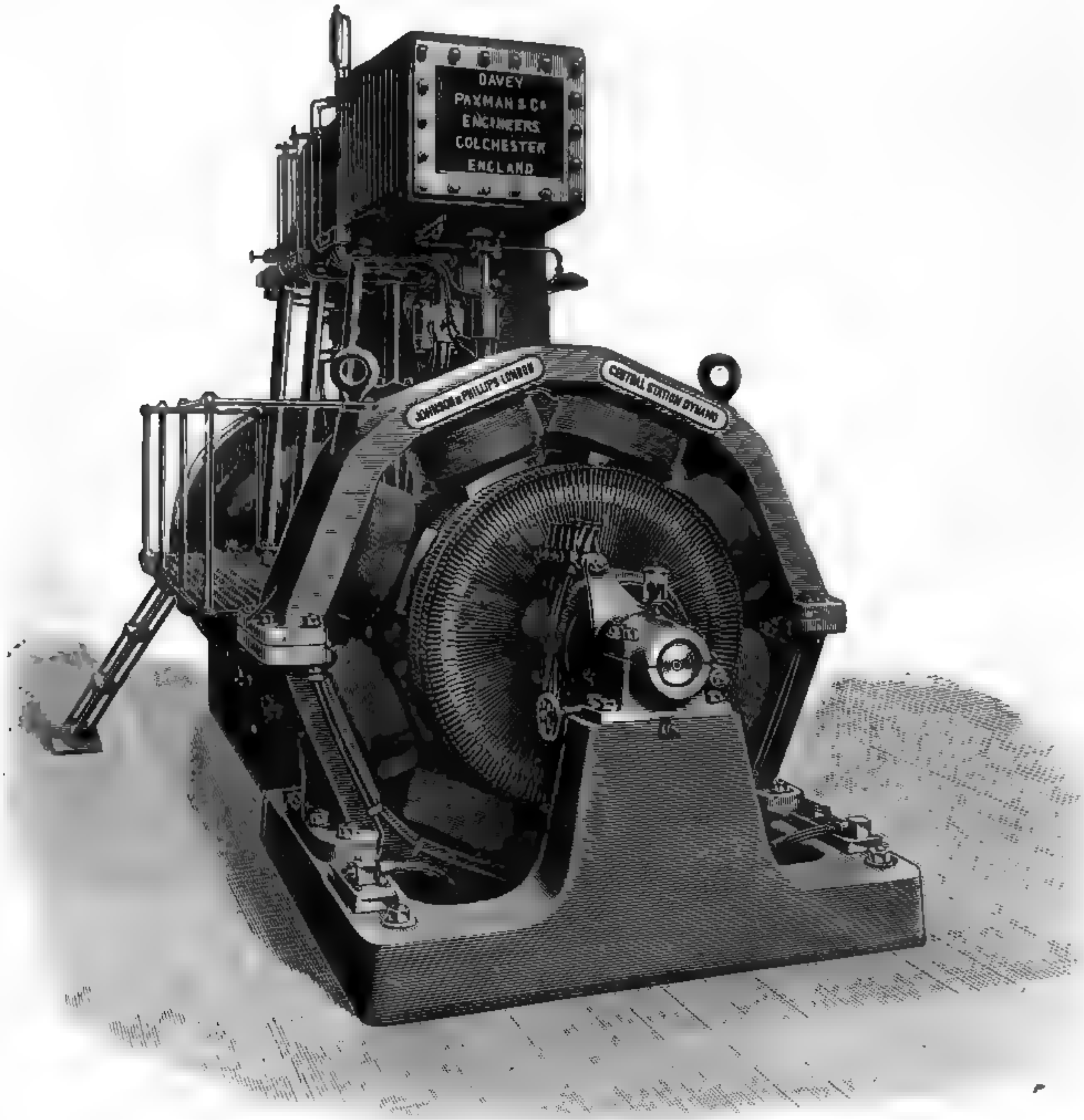
I propose to give the adjoining list of dynamos and their details before going on to the description of the various types and their respective advantages. It will then be handy for reference and for comparing the details of the several machines.

The first five columns of the list need no comment. In the sixth I have reduced the circumferential speed of the core to 2,000ft. per minute, and then obtained the output of the dynamos on the assumption that the E.M.F. alone varies, and that as the speed. This is not absolutely correct, as with the higher speed the cooling surface on the armature is more effective, and so a larger current can be obtained without increasing the rise of temperature. It is, however, a good approximation, and as the circumferential speeds of the machines lie on each side of this, it is the best that can be taken.

In the next column the type of field magnet is given. There will also be illustrations of each type appearing either in this issue or the next, to which reference can easily be made. In the weight efficiency column is given the number of kilowatts obtained from each ton of material when the circumferential speed is 2,000ft. per minute. It is interesting to note that small belt-driven machines stand highest in this respect. Messrs. Easton and Anderson take the first place. This is due to the fact that they require a small magnetising force, and consequently short magnets, in their dynamos. On the whole, the outputs per weight obtained agree very closely. Messrs. Crompton and Co. obtain the highest output per weight in the large dynamos, but the eight-pole machine made by Messrs. Johnson and Phillips is near them, and this dynamo has cast-iron field magnets. The multipolar machines thus give high weight efficiencies, and it is interesting to note in the two-pole machine made by Messrs. Siemens Bros. how the weight efficiency falls with the increased output. The output in kilowatts per square foot of floor space is given in the next column. In taking the floor space I measured always the extreme breadth and width. In the case of coupled plant I took the length from the end up to the middle of the coupling, and in the belt-driven machines up to the pulley. These square dimensions make the results too low for a few dynamos, but gives on the whole the most useful information. Messrs. Siemens Bros. and Co. obtain the highest figure in this floor space efficiency with their 23-kilowatt machine, and Messrs. Johnson and Phillips take the second place with their large dynamo. There is much more variation amongst the figures in this column than in the last, and I shall refer to it again when considering the different types. It must be borne in mind that the outputs on which these calculations are based are those given by the makers, and arbitrarily fixed by them. Therefore they do not necessarily correspond to the same ultimate rise of temperature in the armature. This rise should be the basis of comparison, and I hope that the jury

of experts will publish information that will lead to the adoption of definite standards of output.

The only other details requiring comment are the last three columns. The total induction at full load is calculated in every case where the number of turns are given. The induction per square centimetre in the armature core has in each case been calculated by myself upon the details given to me by the makers. This is only approximate, as the allowance made for ventilation and paper or shellac, etc., varies with different firms, and I may have allowed too much or too little. The leakage of magnetism also is different for different types of field magnets, and so I have not introduced it into my calculations for this list. The figures given in the last column show the density of useful lines in the field. By useful lines, I mean the lines which actually pass through the armature. To obtain the real induction in the magnets, the values given would have to be increased by from 15 to 50 per cent., according to the type.



Johnson and Phillips' 8-pole Dynamo.

1882—1892: A COMPARISON.

BY SYDNEY F. WALKER.

To those who can remember the exhibition which was held at the Crystal Palace in 1882, the present one will afford matter of considerable interest.

In 1882 the incandescent lamp had only recently been born, and though largely exhibited was yet very expensive, very uncertain, and could boast of only one form—the plain 20-c.p. type, with platinum loops. To-day, the glow lamp is everywhere in evidence, is used without fear of being left in the dark, and is made in every form that the wit of man has so far been able to devise.

To-day, too, in place of modestly showing itself with deference to its earlier rival—the arc lamp—it is boldly invading the domain hitherto solely occupied by the arc itself. In those days—the gas shares had but recently recovered from the severe panic which ensued on Mr. Edison's announcement that he had solved the problem of the division of the electric light, and gas managers had seen fit to put their house in order—gas was still king. Gas managers laughed heartily at the recent scare, and boldly declared that the electric light could never displace them. "We can give away the gas we make and yet pay a good dividend," they said. Now gas undertakings all over the country, the wisest of them, are seeking to get themselves bought up by local authorities while there is yet time. Gas directors and gas managers still talk of the absurdity of being driven off the field by electricity, but they no longer sneer at the rival illuminant—whether they acknowledge it or not, the handwriting is on the wall. Gas has been tried in the balance and found wanting. Stranger still, the very failing with which electric lights were branded

in early days (their constant habit of flickering) has been turned against gas itself. The light given by the glow lamp is preferred, not only for the purity of the atmosphere its use entails, but more for its steadiness.

In 1882 gas always accompanied the electric light, because the latter was so liable to go out, and it was on gas that managers relied for illumination. To-day, you will still see gas burners here and there where the glow lamp has been adopted, but it is in an even more modest form than its rival assumed 10 years ago. Gas may be seen in some out-of-the-way position where it can be brought into use in case of accident. Few of those who were engaged in electric lighting work in those days dared to hope for the advances that have been made in the past 10 years.

Passing on, however, from the improvements that have been made in glow-lamp work, one cannot but be struck with the small comparative advances that have been made in arc lights. It is true they do not now go out altogether, nor is it often that even an individual lamp becomes extinguished in any installation that is well looked after. But the lamps themselves flicker even more, one and all, than the best arc lamps did as far back as 12 years ago. The lamps have been improved, it is true. They are made and designed better than in days gone by, but they are still very unsteady. If anyone doubts this, let him sit for half an hour in any place illuminated entirely by arc lamps, and watch the behaviour of each lamp. Audiences do not notice it possibly, though some complain of the unsteadiness very much. In the majority of cases, though, the great volume of light given masks the unsteadiness of individual lamps, but it is apparent to anyone who has eyes to see. Let any unprejudiced observer note this fact, note the growing favour with which the soft steady glow lamp is being received, and then read the future history of electric lighting. Once more, the handwriting is on the wall. In the rapid march of the electrical revolution now in progress, older ideas must go under; tools that have done good service in their day must be displaced by later and more improved ones. If gas must go—and that is as certain as anything can be in this world—so must the arc lamp.

Looking back once more to the days of the last exhibition at the Crystal Palace, then the compound-wound dynamo was also but just coming into being. It was even thought in those days that for glow-lamp work the shunt-wound dynamo would be the machine *par excellence*. If the shunt-wound machine had a rival, it was the alternator. Ten years have wrought curious changes in these as in other points. The shunt-wound machine and the alternator have both given place to the compound-wound dynamo for all but large supply stations. For the latter shunt-wound machines and alternators rule, but the alternator is not the machine of 10 years ago. The alternator of 10 years ago is dead, except a few specimens, but in its place has arisen a giant bearing the same name.

One cannot help according a tribute to the foresight of Mr. Edison on the matter of shunt-wound machines for central stations. As we know, his ideas of 10 years back were worked out for central stations, and were carried into practice by him in his own district. In this country we were not ready for central stations in 1882. Even Mr. Edison's own exhibit at the Holborn Viaduct did not impress us; and the small copies, the applications of parts of the system to small installations, were necessarily doomed to failure. To-day, the supply companies which pay the best use Edison's system, with the addition of storage batteries.

Storage batteries, too, in 1882 had been recently boomed, have since afforded a good financial harvest to individual speculators; have been ridiculed as failures, and are now rearing their heads once more as the result of years of hard persistent labour upon them. To-day, though the storage batteries in the market leave much to be desired, we yet have them doing active practical work, and, what is more, earning money for those who employ them.

In the 10 years that are past, though the arc lamp proper has remained, the lamp which at one time threatened to extinguish it has itself met that fate. Jablochkoff's candle can be seen occasionally as a rare curiosity. Jamin's candle has gone, Wilde's has too, and so has La Soleil. Yet, strangely enough, out of the ashes of Jablochkoff's undoubtedly remarkable invention arises the apparatus with which one section of electrical engineers are meeting the problem of distribution over large areas, and meeting it successfully, too, so far as work goes. Possibly dividends may come after. Who would have supposed that when Jablochkoff described his beautiful apparatus for the subdivision of the electric light—from which we all hoped so much then, and which we saw doomed to failure with feelings of the deepest regret—that the induction coil, upon which he based his plans, would be of so much service so many years after? Jablochkoff's invention belongs, of course, to 1878, but his lamp was fully in evidence in 1882.

During the 10 years, too, what changes have taken place in the construction of dynamos! We have seen the output of old types enormously increased, and the efficiency of all types steadily rise. Thanks also to Dr. Hopkinson and Mr. Kapp, we are no longer compelled to plunge wildly round seeking for experimental fact upon which to base our construction. We know the laws of our machines fairly well, and are able to design and construct them to fulfil most of the requirements that are asked for. What revolution and counter-revolution has also taken place in the matter of the speed at which we should drive the armatures of our dynamos. Shortly after 1882 we were assured that high speeds were bad, irretrievably. It was of no use pointing out that a light armature might safely be driven at a much higher speed than a heavy one; just as a circular saw, or an emery wheel can be. Circular saws are not dynamos, was our answer. Dynamos *must* be driven slowly. Later on, however, possibly compelled by the exigencies of the market, the same dictators discovered that it was not economical to waste metal. If a machine of a given weight came to no harm when driven faster in the hands of those to whom it was sold, why not sell it to be driven faster, and so get a higher price for it? It is a grave question if the matter of fast driving has not been carried too far lately, not on the dynamo, but in the engine. The gentlemen who designed and constructed many of the engines that are running at the Crystal Palace may have some wrinkles not possessed by outsiders, but unless they have, their engines running at the high speeds shown there are practically sure to give trouble later on—300ft. per minute used to be the old rule for the speed of engine pistons. Excellence of workmanship and of lubrication have enabled younger engineers to go as far as 400ft. and even 450ft. per minute, but many of those shown must be running at very much higher speeds than are indicated by these figures, and these are looked upon with considerable fear by older men. If those who have the designing of these engines will be wise in time, they will reduce their speeds. It is a good thing, a very good thing, to drive your dynamo directly from the engine, but it is not wise to knock your engine to pieces in order to accomplish this. Better than do that sacrifice something of the output of the dynamo and lower its speed.

Passing on to other apparatus. What a contrast between the telephone exhibits in 1882 and those to-day! One glance at the Consolidated Company's stall will show the enormous advances that have been made, notwithstanding all drawbacks, in developing the adaptability of the apparatus. Now you can have a telephonic apparatus fitted for almost every conceivable position you may find yourself in.

In 1882 also, it will be remembered, the great fight was just commencing; now, after it has been fought, the victory won and used to the full power given, the field is once more open, and we may hope for larger and larger developments.

The writer has few more remarks to make. New firms, and many of them, have sprung into existence since 1882; many of those in existence then are no more. How many will be still alive in 1902? New forms of gas engines seem as numerous as new forms of dynamos, and, like the latter, seem all somehow very much alike, though each claims some special feature of its own. One great and long-desired invention the past decade has not given us—viz., an electric miner's lamp. Many are the lamps that have

been invented; none have so far survived the practical test of actual mining work as to warrant their adoption in large numbers. The writer ventures to offer a reason for this—viz., that those who could produce such a lamp have no inducement offered them to leave other work in order to do so. It is well known that no invention for an electric miner's lamp can be held in the face of a long purse opposed to it; consequently, those who would have a fair chance of success are content to leave "some other fellow" to invent a lamp, while they devote their time and money to things that offer a better prospect. One hint, however, may be given. No test that can be applied in London, or in any hands but those accustomed to mining work, can be of the smallest value, and any money spent on such tests will be simply thrown away. Whether the primary or the secondary battery proves to be the successful one, experience only can decide. In the writer's opinion, the former has the best chance.

THE "TIMES" ON PHONOPORIC TELEPHONY.

An article in Wednesday's *Times* on this subject is to the following effect: "We have upon previous occasions noticed the progressive development of that ingenious and remarkable outcome of electrical research, the phonopore, which comprises a system of multiplex telegraphy. The phonopore is the invention of Mr. Langdon-Davies, and the peculiarity of the instrument is that by it messages can be sent and received in either direction simultaneously with the ordinary telegraph service over the same line and without affecting or being affected by the working of the ordinary service, so that two independent services are worked on one wire. Since our last notice, which appeared just three years since, considerable advances have been made in the practical application of the phonopore, it having been adopted on the Midland, the Great Western, and the Great Eastern Railways. A contract is also pending for its adoption on the Great Northern Railway, and it has been largely adopted abroad. Since that time also Mr. Langdon-Davies has developed into practical use a new departure in the application of the phonopore to telephonic purposes, and it is in this connection that we now have to notice it. In order, however, to ensure a clear understanding of the action of the phonopore it is necessary to briefly describe its principles. It is well known that if a telephone be inserted in a wire situate near telegraph wires noises are produced in the telephone by the passing currents in the telegraph wires, although the telephone wire is perfectly insulated from the wires of the telegraph. These are the noises of induction, and in trying to obviate their effects in the telephone Mr. Langdon-Davies made the discovery which led to the invention of the phonopore. By means of this instrument he separates induction—which is a form of electrical force -from the currents, and passes it freely through insulations which are impassable by currents. He utilises this force in a novel series of instruments, which are capable of being put in operation in company with current instruments on the same wire. In a word, Mr. Langdon-Davies most ingeniously collects and utilises what may be termed the waste products of ordinary telegraphic currents—namely, noises. The result, which is very remarkable, is that phonoporic messages are transmitted and received through an ordinary live wire by the phonopore while at the same time telegraphic messages are being transmitted and received through the same wire by the ordinary telegraphic apparatus. Nor is it less remarkable that the phonoporic instruments have no metallic conducting circuit through them. The phonopore gives uninterrupted passage to electrical effects capable of being associated with sound, although it does not permit the passage of electric currents. The earlier announcements of these peculiarities were received not only with doubt, but with ridicule in electrical circles, with a few important exceptions. Electricians have, however, lived to see the adoption of the phonopore for everyday use, while some of them have reported in the strongest terms in favour of its practical utility.

"The principles of the phonopore having been explained, we will now consider its application to telephony. The example we shall take is that afforded by the Great Western Railway, on which line phonoporic telephony has been applied as a first installation between two signal-boxes at the Southall and Brentford Stations respectively, their distance apart being about 3½ miles. We were recently afforded the opportunity of inspecting the working of this installation by the Phonophore Syndicate, of Blomfield House, London-wall, London. The striking feature here is that the telephone is installed on a block signalling wire, a wire which has hitherto been sacred to block signalling alone, and very properly so, inasmuch as the safe working of a railway depends upon the block wires being kept absolutely inviolable against all interruption. But it has long been felt that telephonic communication was a very desirable thing to have between the signal-boxes, and railway companies have been using their best endeavours to effect this in various ways. As far as we are aware, however, they have not been successful, inasmuch as the schemes propounded involve the temporary interruption of the block wire, and, as we have pointed out, this wire must not be interfered with for a single moment. Hence down to the present telephonic communication between signal-boxes has not been established. But the interposition of the phonopore has enabled this to be done most effectually, and by means of this apparatus in connection with the telephone speaking communication is now maintained between the two points mentioned, while the wire employed is being used simultaneously for block signalling purposes without the two services on the same wire in any way interfering with each other. This is an entirely new achievement in telegraphy, and one which cannot fail to prove of leading importance to railway companies. This application of the phonopore to telephony is the first practical outcome of a long series of results worked out experimentally and successfully by Mr. Langdon-Davies five years ago, but which were laid aside by him in order that he might perfect the application of the phonopore to telegraphy."

CORRESPONDENCE.

'One man's word is no man's word,
Justice needs that both be heard.'

COMMUTED CURRENTS.

SIR,—I have always thought that the expression "continuous current" is unhappy and incorrect where it is applied to a current consisting of a separate impulse from each coil of the armature on passing the gap, and more especially from those machines where each coil is cut out of the circuit on reaching the field-horn after passing the gap. Would not the word "commuted" convey a more correct idea? When a current passes from a primary or secondary battery, then the current is, of course, continuous, and the expression "continuous" is correct. I think a distinction should be made in describing these two different currents. They cannot be alike in their action, and doubtless the delicate filaments in incandescent lamps feel the difference.—Yours, etc.,

W.

Kidderminster.—The Kidderminster Town Council are understood to be prepared to transfer their provisional order for electric lighting to an outside company, for the purpose of taking up the lighting in that town. A company has been in negotiation with the Corporation, and an engineer has visited the town to see what demand might be expected, but reported that the number of large houses were not great, and that he thought it would hardly be worth the Corporation's while to take up the lighting themselves. The question was discussed at the last Town Council meeting, and it was resolved to wait until a definite offer had been received. Something should be done at once, however, or the Corporation will lose (or rather have to renew) their order. The question was left in the hands of the Improvement Committee.

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INCREASING THE SUPPLY.

Electric station engineers, especially those in London, find themselves face to face with an important problem which will, sooner or later, have to be seriously tackled. The number of customers to any central station at its first inception increases with a rush as the advantages of the electric light are brought home to users. But after one or two years' regular working, it is found, especially in certain populous residential districts, that a curious falling off is experienced in the rate of increase of customers. Careful enquiries are, of course, instituted as to this hesitancy—as to whether it be the cost of the light, fears as to its danger or steadiness, or what not. The answer is a complete vindication of any such charge against either the usefulness or price of the electric light. It is found to be simply the cost of outlay for the wiring and fittings. But surely persons who can afford the light, we should answer, would be able to afford to pay for fittings. So they might, if these fittings became their own property—but they do not. Many of the inhabitants of the districts we are speaking about hold their houses on short leases, perhaps with only a year or two to run. The lease usually contains clauses that no alterations in gas mains and so forth may be undertaken without consent of the landlord, or if the consent of the landlord be obtained it is simply under the condition that such fittings be paid for by the tenant, but remain the property of the landlord. Tenants on short leases are not so anxious to improve the property of the landlord at their own expense as to wire up the house throughout, and then make over the material to the landlord at the expiry of the lease, and consequently they do without the light. The electric light fittings, as usually laid in a house, come under the heading of fixtures, and as such therefore become the property of the landlord on the expiry of the lease.

This state of things threatens to become very serious to the spread of the electric lighting industry, and if electrical engineers and directors of electric supply companies wish to extend the use of electric light to its utmost extent, steps must be taken to overcome this deadlock. There are two or three means which might be taken to meet the difficulty in a practical spirit which will, no doubt, suggest themselves to commercial men, but we shall, perhaps, be doing a helpful act in mentioning these specifically. In the first place, it would evidently meet the requirements of those who require the electric light for parties, balls, and other special occasions, if all or most of the electrical contractors were to make terms with artistic fitting manufacturers, such as Faraday's, Osler's, and others to have the control of handsome complete sets of ballroom or dining-table fixtures, such as are shown at the Crystal Palace, to be hired out at a fixed sum per night, the current to be supplied by accumulators. This has already been carried out to some extent among the richer class of householders, but the practice might very well be extended, and might even give work to an "Electrical Fittings Hire Company, Limited." But this only satisfies one portion of the demand. There remain

those who desire a steady supply, but do not wish to pay for the wiring of the house on the chance of losing the whole amount after a year or two. To deal with this difficulty another scheme must be adopted. The fittings should be arranged so that they do not become "fixtures," and a discussion in a friendly way between electrical contractors and the fire office inspectors, ought to reveal without much difficulty a means for achieving this result. The cables, wires, fittings, lamps, meters, and blocks should be arranged so that they are not attached directly to the house itself, but remain removable property. This could no doubt be arranged with but little change from the usual system. We think we can foresee here, however, a good opening for the use of concentric wires, which, if strung up on insulators in a house, could be removable at the end of a tenancy, and would remain the property of their purchaser. The incoming tenant could be asked if he desired to take the electric light, and if not, the whole apparatus could be promptly dismantled for use elsewhere. We need hardly emphasise the fact that it would be directly to the interest of the directors and shareholders of electric supply companies to encourage and foster firms or hire-companies who would undertake this work.

AN EARLY CONCEPTION OF THE MAGNETIC FIELD.*

BY PROF. EDWIN J. HOUSTON.

It may interest the members of the Electrical Section to know that as early as 1668, Robert Boyle, the eminent physicist and chemist, published, concerning the magnetic field, exceedingly advanced ideas which closely resembled the modern ideas of magnetic flux and lines of magnetic force.

Boyle's publication, so far before the time of Faraday, shows the exceedingly advanced position he must have occupied at that early date, as a thinker and investigator in physical science.

Boyle was an indefatigable worker, and a voluminous writer, both in the domain of physics and chemistry, as well as that of medicine. He taught that absolute rest had practically no existence even in bodies in apparent rest, since there existed in such bodies what is called an intestine motion of their particles. He also had original notions of what was called, in his time, effluvia, and it was in connection with these so-called effluvia that he advanced an explanation concerning the magnetic action of the loadstone, which bears a remarkably close resemblance to the modern ideas of a magnetic field and lines of magnetic force.

The quotation referred to is from the second of two essays "Concerning the Unsuccessfulness of Experiments," published in 1668. In these essays he has been pointing out the necessity for care in conducting scientific experiments, and urges that the failure to experimentally reproduce any natural phenomenon should not necessarily call in question the accuracy of the first observer of such phenomenon, until all the sources of error that might have led to obscuring or vitiating it had been eliminated. In this connection he cites, in a quaint manner, some of the numerous experiments that he had been led to try on the assertion of well-known scientific men, but in which he failed to obtain the results alleged to have been observed. He describes in this connection the magnetisation produced by touching a steel knife-blade to the armed pole of a loadstone as resulting in different polarities according to whether the point of the blade is drawn towards or from the equator of the loadstone.

I will quote Mr. Boyle's remarks in full in this connection: "If on either of the extremes or poles of a good armed load-stone, you leisurely enough, or divers times, draw the back of a knife, which has not before receivd any magnetick influence, you may observe that if the point of the blade have in this affriction been drawn from the middle or æquator of the load-stone towards the pole of it, it will attract one of the extremes of an equilibrated magnetick needle; but if you take another knife that has not yet been invigorated, and upon the self-same extremity of pole and the load-stone, thrust the back of the knife from the pole towards the æquator or middle of the load-stone, you shall find that the point of the knife has by this bare difference of position in the blade whilst it past upon the extreme of the the load-stone, acquired so different a magnetic property, or polarity, from that which was given to the former knife by the same pole of the load-stone, that it will not attract, but rather seem to repel or drive away that end of the magnetick needle which was drawn by the point of the other knife. And this improbable experiment not only have we made trial of, by passing slender irons upon the extremities of armed load-stones, the breadth of the whose steel-caps may make the experiment somewhat less strange, but we have likewise try'd it by affrictions of such irons upon the pole of a naked terella, and we have found it to succeed there likewise. How strange soever it may seem, that the same point or part of the load-stone should imbue iron with contrary properties, barely as they are, during their passing over it, drawn from the æquator of the load-stone, or thrust towards it. But whether, and how far this observation insinuates the operations of load-stone to be chiefly performed by streams of small particles, which perpetually issuing out of one of its poles, do wheel about and re-enter at the other; We shall not now examine (though this seem one of the most likely phænomena we have met with, to hint a probable magnetical hypothesis) contenting ourselves to have manifested by what plainly appears, how much influence a circumstance, which none but a magnetick philosopher would take notice of, may have on an experiment."

Mr. Boyle had obtained an insight into the actions which occur during magnetisation far beyond that of his contemporaries. This fact appears to be clearly indicated by the above statement as to what he believed to be the actual operation of the loadstone—namely, that it produced magnetisation by means of streams of small particles coming out of one pole and re-entering at the other pole. Change the phraseology but a trifle, and leave the ideas as expressed, and we have at this early date a fair idea of the modern notion of magnetic flux.

Boyle's notion seems to have been that when other bodies were brought into this magnetic stream, they became endowed with magnetic properties by the particles or corpuscles forming the stream, passing through them, just as we now explain magnetisation by the passage through a magnetisable substance of the lines of magnetic force.

In a later paper, published in 1669, on "The Absolute Rest of Bodies," he asserts that the particles even in exceedingly dense substances that are apparently at rest are, in reality, in rapid motion. He urges that although such motions cannot be seen, yet they must exist, and cites as a proof of such assertion the following experiment, which I will give in Mr. Boyle's language:

"I briefly answer (for I would not here repeat what I have elsewhere said on this point) by this clear experiment, that though your eye can discern no change in the outward and visible, much less in the more latent and internal corpuscle of iron: a vigorous load-stone by passing along its axis from one pole of the stone to the other, and back again, yet the texture of the iron is by that action of the load-stone so changed, that it acquires, and then loses those admirable qualities we call the attractive and directive virtue or faculty peculiar to magnetick bodies."

And further on, in the same paper, in speaking of the well-known fact that a mass of steel when allowed to stand in an upright position for some time on the earth, is endowed with magnetic properties, he ascribes these properties to the action which the streams of corpuscles exert on it.

"To this purpose I shall only observe to you th

* Paper read at a meeting of the Electrical Section of the Franklin Institute.

a bar of iron having one of its ends held perpendicularly, and at a fit distance to the Lilly or northern point of the mariner's compass (I mean that which points towards the north), it will, as I elsewhere mention, drive it away towards the east or west; and if this same lower end of the bar of iron be put into a contrary posture it will presently lose its temporary magnetism, as I elsewhere declare. Yet if this bar be very long-kept upright in a window or other convenient place, then, as some late magneticknal writers will tell you, it will have acquired a constant and durable magnetick power. Which is a phenomenon which makes exceedingly for our present purpose, since it hence appears both that the air together with the magnetical effluvia of the earth that it receives in its pores, is able without outward force to work durable changes in so solid a body as iron, and that the motions of the internal parts, for these are requisite to change the metal's texture, are performed with a wonderful slowness since the bar must be very long exposed to the air, perhaps before it acquires any durable magnetism at all, but at least before it acquires so vigorous and fixt a magnetism as by this means it may attain to."

In another paper on "The Nature, Properties, and Effects of Effluvia," reproduced by Shaw at a later date, in vol i., p. 411, of the philosophical works of the Hon. Robert Boyle, Esq., 1725, Boyle writes as follows:

"To clear this matter, I caused some needles to be hermetically sealed up in glass pipes, which being laid on the surface of the water, whereon they wou'd lightly float, the encluded needles did not only readily answer to the loadstone externally applied, tho' a weak one, but comply'd with it so well that I cou'd easily lead, without touching it, the whole pipe to what part of the surface of the water I pleased. I also found that by applying a better load-stone to the upper part of the seal'd pipe, with a needle in it, I cou'd make the needle leap up from the lower part, as near to the load-stone as the interposed glass wou'd give it leave. But I thought it more considerable to manifest that the magnetical effluvia, even of such a dull body as the globe of the earth, wou'd also penetrate glass. And this I attempted after the following manner. I took a cylindrical piece of iron, about the bigness of one's little finger, and between half a foot and a foot long; having formerly found that the quantity of unexcited iron forwards its operation upon excited needles; and having hermetically seal'd it up in a glass pipe, but very little longer than it, I suppos'd that if I held it in a perpendicular posture, the magnetical effluvia of the earth, penetrating the glass, wou'd make the lower extreme of the iron answerable to the North Pole; and, therefore, having applied this to that point of the needle, in a dial or sea-compass, which looks towards the north, I presum'd it would drive it away, which accordingly it did. And having, for further trial, inverted the included iron, and held it in a perpendicular posture, just under the same point, that extreme of the iron rod, which before had driven away this point, being, by inversion, become a south pole, attracted it; from which sudden change of the poles, merely upon the change of the situation, it also appeared that the iron owed its virtue only to the magnetism of the earth; not that of another load-stone which wou'd not have been thus easily alterable."

I need not call your attention to the marked similarity between the manner in which Boyle conceives magnetic induction to take place, and our modern notions concerning the same phenomenon. His streams of magnetic effluvia correspond exactly in direction and action to our present conceptions of magnetic flux and lines of magnetic force.

Coming now to the time of Faraday, we find in a paper, published by Faraday in the *Philosophical Transactions*, in 1852, the following: "From my earliest experiments on the relation of electricity and magnetism, I have had to think and speak of lines of magnetic force as representations of the magnetic power, not merely in the points of quality and direction, but also in quantity. . . ."

"A line of magnetic force may be defined as that line which is described by a very small magnetic needle, when it is so moved in either direction correspondent to its length, that the needle is constantly a tangent to the line of motion. . . ."

"These lines have not merely a determinate direction recognisable as above, but because they are related to a polar or antithetical power, have opposite quantities or conditions in opposite directions. These qualities, which have to be distinguished and identified, are made manifest to us, either by the position of the ends of the magnetic needle, or by the direction of the current induced in the moving wire."

As to the direction of the lines of magnetic force, Faraday, as is well known, regarded them as coming out of one pole of the magnet and passing in at the other pole, and referred to this in a paper printed in the *Proceedings* of the Royal Institution, on the 23rd of January, 1852, as follows:

"The lines of force already described will if observed by iron filings or a magnetic needle or otherwise, be found to start off from one end of a bar magnet, and after describing curves of different magnitudes through the surrounding space, to return to and set on the other end of the magnet."

There is, of course, a danger in quoting from an early writer, of reading into the quotation a significance that it could not have had, save by the light of subsequent researches. It is far from my purpose, or desire, to belittle the researches of Faraday. I merely desire to show, by a comparison of the writings of these two philosophers, the remarkable advance that Boyle had made as to the manner in which a magnet acts.

In the above quotation from Boyle it must be remembered that Boyle referred to certain effluvia which he believed were given off by the magnet. His conception, however, of these particles coming out at one pole and re-entering the other, and his mentally endowing streams of such particles with polarity, or the possession of opposite properties in opposite directions, was certainly a remarkable advance for his times, and shows how far he was beyond his contemporaries.

It is possible that other writers before the time of Boyle, or between his time and that of Faraday, may have expressed somewhat similar ideas. I merely call your attention to the quotations from Boyle as showing the remarkable grasp of magnetic phenomena possessed by this early philosopher.

ON THE CLARK CELL AS A STANDARD OF ELECTROMOTIVE FORCE.*

BY R. T. GLAZEBROOK, M.A., F.R.S., FELLOW OF TRINITY COLLEGE, AND S. SKINNER, M.A., CHRIST'S COLLEGE, DEMONSTRATOR IN THE CAVENDISH LABORATORY, CAMBRIDGE.

The paper consists of two parts. In Part I. an account is given of experiments on the absolute E.M.F. of a Clark cell. This was determined in the manner described by Lord Rayleigh (*Phil. Trans.*, 1884) in terms of a known resistance and the electro-chemical equivalent of silver. The resistance used was a strip of platinoid about 1 cm. wide and 0 05 cm. thick wound on an open frame. It was immersed in a bath of paraffin oil, and the currents used, varying from about 0·75 to rather over 1·4 amperes, did not raise its temperature sufficiently to affect the result. It had a resistance of nearly one B.A. unit. This was determined in terms of the original B.A. units. As part of the object of the experiments was to test the memorandum on the use of the silver voltameter recently issued by the Electrical Standards Committee of the Board of Trade, the large currents mentioned above were purposely employed. The silver voltameters were treated in accordance with the instructions in the memorandum.

The standard cell to which the results are referred is one constructed by Lord Rayleigh in 1883, probably No. 4 of the cells described in his paper already quoted. The results have been reduced on the supposition that one B.A. unit is equal to 0 9866 ohm; if we take the number 0·9535† as representing the value in B.A. units of the resistance of a column of mercury at 0deg., 1 metre long, 1 sq. mm. in section, the above is equivalent to saying that the length of the mercury column having a resistance of one ohm is 106·3 cm. It has also been assumed that the mass of

*Abstract of a paper read before the Society of Arts.

† This number is the mean of the best recent results

silver depoisted in one second by a current of one ampere is 0·001118 gramme, and that the coefficient of change of E.M.F. with temperature of a Clark's cell is 0·00076. This last result has been verified by us in Part II. An account of nine separate experiments is given in the paper; the following are the results reduced to 15deg. C.:

No. of experiment.	E.M.F. of cell.	No. of experiment.	E.M.F. of cell.
1	1·4341	6	1·4342
2	1·4336	7	1·4342
3	1·4341	8	1·4340
4	1·4340	9	1·4345
5	1·4340		

The mean of these is 1·4341, or, correcting for the rate of the clock, 1·4342.

In Experiment 2 the current in the voltameter was rather unsteady, which may account for the low value; while in Experiment 9 the temperature of the cell was changing somewhat, and our later experience has shown us that the E.M.F. in our standard cell lags very considerably behind the temperature. Still, even taking these experiments into account, the results are very close.

If we suppose, as seems most probable, for reasons given in the paper, that our cell is No. 4 of Lord Rayleigh's paper, and that it has retained relative to No. 1 (Lord Rayleigh's standard) the value it had in 1883, the E.M.F. of his cell No. 1 would be in the units he used, 1·4346 volts at 15deg. The value found by Lord Rayleigh was 1·4348 volts; thus the two are very close.

In the units we have given above, those specified by the Board of Trade, we have finally the result that the E.M.F. of our cell is 1·4342 volts at 15deg. C. or 1·4324 volts at 62deg. F.

Part II.

In the second part of the paper we have investigated some of the sources of error in the Clark cell, and also the effects of small variations in the materials used and the method of their preparation. We have also compared a number of cells set up by different makers. The general result is a very good agreement among cells from very various sources.

Cells set up by Lord Rayleigh in 1883 and 1884, Mr. Elder in 1886, Mr. H. L. Callendar in 1886, Dr. Muirhead in 1890, and by Dr. Schuster, Mr. Wilberforce, and ourselves during the past year, all agree closely, the variations among them being rarely greater than about 0·0005 volt. The first set of cells, 18 in number, constructed for the purposes of this enquiry, were made according to Lord Rayleigh's instructions, using, however, various specimens of the chemicals. These showed some differences at first, but in the course of about two months they had all, with one exception, settled down to close agreement with the standard. The exceptional cell has since become normal. In two of these cells mercury was used which had been taken direct from the stock in everyday use in the laboratory. The E.M.F. of these cells was much too low at first, but it gradually increased, and they are now normal. The mercurous sulphate appears to free the mercury from certain harmful impurities.

Another set of cells were put up, in accordance with the provisional memorandum of the Electrical Standards Committee of the Board of Trade, issued in June last and quoted below.

Memorandum on the Preparation of the Clark Standard Cell.

Definition of the Cell.

The cell consists of mercury and zinc in a saturated solution of zinc sulphate and mercurous sulphate in water, prepared with mercurous sulphate in excess, and is conveniently contained in a cylindrical glass vessel.

Preparation of the Materials.

1. *The Mercury.*—To secure purity it should be first treated with acid in the usual manner, and subsequently distilled in vacuo.

2. *The Zinc.*—Take a portion of a rod of pure zinc, solder to one end a piece of copper wire, clean the whole with glass paper, carefully removing any loose pieces of the zinc. Just before making up the cell, dip the zinc into dilute sulphuric acid, wash with distilled water, and dry with a clean cloth or filter paper.

3. *The Zinc Sulphate Solution.*—Prepare a saturated solution of pure ("pure recrystallised") zinc sulphate by mixing in a flask distilled water with nearly twice its weight of crystals of pure zinc sulphate, and adding a little zinc carbonate to neutralise any free acid. The whole of the crystals should be dissolved with the air of gentle heat—*i.e.*, not exceeding a temperature of 30deg. C.—and the solution filtered, while still warm, into a stock bottle. Crystals should form as it cools.

4. *The Mercurous Sulphate.*—Take mercurous sulphate, purchased as pure, and wash it thoroughly with cold distilled water by agitation in a bottle; drain off the water, and repeat the process at least twice. After the last washing, drain off as much of the water as possible. Mix the washed mercurous sulphate with the zinc sulphate solution, adding sufficient crystals of zinc sulphate from the stock bottle to ensure saturation, and a small quantity of pure mercury. Shake these up well together to form a paste of the consistency of cream. Heat the paste sufficiently to dissolve the crystals, but not above a temperature of 30deg. Keep the paste for an hour at this temperature, agitating it from time to time, then allow it to cool. Crystals of zinc sulphate should then be distinctly visible throughout the mass; if this is not the case, add more crystals from the stock bottle, and repeat the process. This method ensures the formation of a saturated solution of zinc and mercurous sulphates in water. The presence of the free mercury throughout the paste preserves the basicity of the salt, and is of the utmost importance. Contact is made with the mercury by means of a platinum wire about No. 22 gauge. This is protected from contact with the other materials of the cell by being sealed into a glass tube. The ends of the wire project from the ends of the tube; one end forms the terminal, the other end and a portion of the glass tube dip into the mercury.

To set up the Cell.

The cell may conveniently be set up in a small test-tube of about 2 cm. diameter, and 6 cm. or 7 cm. deep. Place the mercury in the bottom of this tube, filling it to a depth of, say, 1·5 c.m. Cut a cork about 0·5 cm. thick to fit the tube; at one side of the cork bore a hole, through which the zinc rod can pass tightly; at the other side bore another hole for the glass tube which covers the platinum wire; at the edge of the cork cut a nick through which the air can pass when the cork is pushed into the tube. Pass the zinc rod about 1 cm. through the cork. Clean the glass tube and platinum wire carefully, then heat the exposed end of the platinum red hot, and insert it in the mercury in the test-tube, taking care that the whole of the exposed platinum is covered. Shake up the paste and introduce it without contact with the upper part of the walls of the test-tube, filling the tube above the mercury to a depth of rather more than 2 cm. Then insert the cork and zinc rod, passing the glass tube through the hole prepared for it. Push the cork gently down until its lower surface is nearly in contact with the liquid. The air will thus be nearly all expelled, and the cell should be left in this condition for at least 24 hours before sealing, which should be done as follows: Melt some marine glue until it is fluid enough to pour by its own weight, and pour it into the test-tube above the cork, using sufficient to cover completely the zinc and soldering. The glass tube should project above the top of the marine glue. The cell thus set up may be mounted in any desirable manner. It is convenient to arrange the mounting so that the cell may be immersed in a water bath up to the level of, say, the upper surface of the cork. Its temperature can then be determined more accurately than is possible when the cell is in air.

These cells, as the tests given show, have been good from the first, and, indeed, we have not had any difficulty with any of the cells in which the instructions of this memorandum have been followed. The mercury used had been distilled in the laboratory, the zincs were supplied as "pure" by Messrs. Harringtons, of Cork, while the zinc and mercurous sulphates came from Messrs. Hopkin and Williams. The numbers in Table I. show the differences between the cells and the standard; the unit is 0·00025 volt.

It may be well to explain the purpose of some of the precautions advised in the circular. The mercurous sulphate, as ordinarily purchased, contains some mercuric sulphate. When this is moistened with water it is resolved into a yellow basic mercuric sulphate (turpeth mineral) and a soluble acid mercuric sulphate. The first, at any rate in moderate quantities, does not affect the E.M.F.; the latter greatly hinders it from attaining the proper value. Repeated washing, however, removes most of this soluble salt. The paste, when made, is shaken with mercury to remove any traces of the acid sulphate which may be left, for the acid mercuric sulphate attacks the mercury and fo

TABLE I.—Differences between a Set of Cells and the Standard.

Date	June 4.	June 6.	June 9.	July 20.	Aug. 6.	Aug. 10.	Aug. 14.	Aug. 22.	Nov. 2.	Nov. 14.	Dec. 17.	July 7*.	July 18.*
Temperature.	16	16	14·5	18	16·2	16·4	17·5	16·4	14·4	9·2	15	15	15
No. 71	−4	−1	−1	0	0	0	0	0	−1	−2	−2	2	−4
,, 72	−3	−1	−1	1	1	0	0	0	1	1	1	3	2
,, 73	−8	−8	−8	1	1	0	1	0	1	1	0	1	2
,, 74	−2	1	2	2	1	0	0	0	1	1	−1	4	2
,, 75	−5	−1	0	0	1	0	1	−1	1	1	−1	4	2
,, 76	−3	2	−1	0	−1	0	−2	−1	1	0	0	2	3

* Comparison with the standard of the Board of Trade. The unit is 0·00025 volt.

sulphate. Careful precautions are necessary to ensure that the solutions should be saturated with both zinc and mercurous sulphates, but the solutions should not be raised in temperature above 30deg. C., for the zinc sulphate may then crystallise out in the wrong form. The proper crystals have the composition $ZnSO_4.7H_2O$, and are rhombic.

But while we have had no serious difficulty with any of the cells prepared in accordance with the last form of the memorandum, some of the other cells we have set up have led to some interesting results. Two sets of cells were put up with great care by Mr. Wilberforce in March and April. One of us (S. S.) set up some cells in the same way about the same time. The solutions were prepared from very pure materials, following Lord Rayleigh's instructions. The zinc sulphate was remarkably free from acid, and it appeared as if the results ought to be good. In the first set, Nos. 36-41, the E.M.F. was too low. At the end of a month it was much too low, about 0·005 volt, and Mr. Wilberforce noticed that a dull grey deposit covered the zincs; he therefore removed them and scraped off this deposit, when, on replacing the zincs, the cells were found to have approximately the normal E.M.F.; they have continued nearly normal since. The next set, Nos. 42-47, were very good when first set up, but the E.M.F. soon fell rapidly, until at the end of a month they were nearly 0·01 volt too low. The grey deposit again was formed over the zinc. Some of these cells were left untouched till August, by which time the E.M.F. had recovered somewhat, being then about 0·005 too low. Others had been treated by removing the zincs and replacing them by amalgamated zincs. In August some experiments were made on the unaltered cells, which showed conclusively that it is necessary that the surface of the zinc should remain bright if consistent results are to be obtained. This bright surface may be secured by amalgamating the zinc, but we are not yet sure that this alone is effective, for it seems possible from various observations that some action which results in the amalgamation of the zinc must go on in the cell to enable it to reach the steady state, and that it may not be sufficient to introduce amalgamated zincs. On this and some kindred points, however, we are still experimenting. The grey deposit can be shown to be mainly mercury in a state of very fine division. There are some indications that a slight acidity in the solutions is of use in promoting amalgamation. We have verified repeatedly an observation of Dr. Hopkinson's that the E.M.F. of a bad cell changes considerably if the cell be slightly shaken, while that of a good cell is not affected.

The paper also contains an account of some experiments on the coefficient of change of E.M.F. with temperature. The value found is 0·000755 per 1deg. C., practically the same as that given by Lord Rayleigh. In this connection we may mention the important observation that when the temperature is rising, even although the rise be only a few degrees, the E.M.F. of the cell may—especially if the cell be large—lag very considerably behind the temperature. On one occasion in which the temperature rose by some 5deg. C. in about a week, the E.M.F. of our large cell at the end of the week corresponded to a temperature nearly 3deg. lower than that given by a thermometer in the bath with the cell, being about 0·0027 volt too high. In this case a thick cake of crystals had formed on the top of the more solid portion of the paste, and the zinc sulphate solution only attained the state of saturation corresponding to the temperature by very slow degrees. Mr. Carhart and Mr. Swinburne have called attention to the difficulties which thus attend the practical use of the cells. They are to some extent met by using small cells.

The paper also describes a new form of portable cell which may be turned into any position without harm. Experiments have also been made on the mercury chloride standards described by Von Helmholtz. A set of these has been constructed which has an E.M.F. of very nearly one volt. A form of standard due to Gouy, in which oxide of mercury is used, has also been examined. The E.M.F. of these cells prepared with yellow oxide is, we find, 1·381 volts, and when prepared with red oxide 1·388 volts.

By the kindness of Major Cardew several of our cells have been compared with the standards of the Board of Trade. The differences are very small, being about 0·0003 volt. The average of the Board of Trade cells is less than our standard by about this amount. The Board of Trade possess 72 cells, and Mr. Rennie, Major Cardew's assistant, informs us that the greatest difference between any two of them is under 0·0007 volt. It will be seen from the table given that, while the cells there considered are on the average about one of our units above our standard, they are rather over two of such units above the Board of Trade cells. Thus our standard exceeds the cells of the Board of Trade by rather over one of our units, or about 0·0003 volt. If we take the E.M.F. of our standard as 1·4342 volts at 15deg., the cells of the Board of Trade average in E.M.F. about 1·4339 volts at 15deg. C., or 1·4321 volts at 62deg. F.

THE ELECTRIC MOTOR: A PRACTICAL DESCRIPTION OF THE MODERN DYNAMO MACHINE, MORE PARTICULARLY AS A MOTOR.*

BY W. B. SAYERS.

(Continued from page 347.)

The Reversibility of the Elementary Principle of the Dynamo Machine.—I have mentioned that if the bar were driven in the magnetic field a back pressure, or opposing E.M.F., would be generated in it, which pressure, or E.M.F., would necessarily be exceeded by the supply pressure. Now, this pressure, which I have called back pressure hitherto, would be generated just the same if the bar were driven across the magnetic field by an external agency. If we were to drive the bar, then, by mechanical power, we should get a difference of electrical pressure, or an E.M.F., between its two ends, which would be capable of producing a current if suitable connections were made. This illustrates the principle of the reversibility of the dynamo machine—our heretofore motor bar is transformed into a generator bar. To go a little further. If we were to apply a constant driving force to the bar (the equivalent of this is done when a constant-current generator is driven by an uncontrolled steam engine supplied with steam at constant pressure), the conditions would be such that through a considerable range the current generated in the bar would be nearly independent of the resistance or back pressure opposed to it, the speed at which the bar was propelled varying so as to produce this result.

* Paper read before the Institution of Engineers and Shipbuilders in Scotland.

For suppose the resistance or the back pressure, or both, opposed to the pressure generated in the bar were to be suddenly increased, the result would be a momentary diminution in the strength of the current; this would mean a corresponding decrease in the force which the driven bar opposed to the constant driving force. The velocity of the bar would consequently be increased, and with it the pressure generated and current in the system, until equilibrium was again restored, which would be when the current had reached its former value. By the reverse process the current would be brought back to its normal value if momentary increase were caused by reduction of the resistance, or the back pressure, or both.

Thus, if suitable low-resistance connections were made between the bar driven by a constant force, and a second similar bar—located, of course, between the poles of a similar magnet—there would be a practically constant current driven through the two bars, so that the constant driving force applied to the one would be transmitted to the second, which we may call the motor bar. This is typical of the transmission of power by what is known as the constant-current system.

Again, suppose one bar to be driven by mechanical power at a constant speed; in this case the pressure generated would be constant, and the mechanically driven bar would then become a source of constant electric pressure, so that if this bar, mechanically driven at a constant speed in a powerful magnetic field, were suitably connected with low-resistance conductor to a second similar bar, the second bar would be driven, at a nearly constant speed, in the manner I have described. This illustrates the principle upon which the transmission of power on the constant-pressure system, in which a constant speed is maintained at all loads, depends.

The Dynamo Machine as a Motor.—The obvious mode of constructing a motor depending for its action upon the elementary forces we have been considering, is to fix the driving bars or wires upon the periphery of a wheel, or drum or cylinder, and to so arrange them and their connections that the forces they exert shall combine to turn such wheel or drum; and further, to so arrange the whole that the rotation shall not relieve the force (so to speak), so that a constant torque is applied to the shaft. This wheel, or drum, with its driving wires (for in small machines the driving bars are merely wires), or its bars and their connections and mountings, form what is called the "armature" of the motor. Many different forms of armatures have been devised, all depending upon the same principles for their actions; but I shall confine myself to the two forms mostly in use in this country—*i.e.*, ring armatures and drum armatures. The essential difference between the two types is this. In a ring armature the connections between the driving wires or bars are taken through the centre of the core, which is a hollow cylinder; in a drum armature the connections between the driving wires or bars are taken across the ends, and there are no connections through the centre.

The drum or ring, as the case may be, upon which the driving bars or wires are mounted, is built up of thin iron discs, with a thin sheet of insulating material between each. It is called the "core" of the armature. If the core were solid, instead of being built up of discs, or laminated in a direction at right angles to the shaft, it would have very powerful electric currents induced in it, caused by the same action which induces the back pressure in the driving bars, and this would result in great loss of energy, and heating of the core. A motor of any size with a solid core would be absolutely worthless from this cause.

The driving bars or wires are constituted by the portions of the "winding," as it is termed, of the armature which cover the periphery,* and may not be separate bars at all; but whether the conducting circuit, or "winding," of the armature is composed of wire wound continuously on, or whether made up of separate bars, such as these I hold in my hand, the primary force which drives the motor is exerted against the core—or against driving pins specially provided—by the wires or bars which cover the periphery of the armature; the force reacting upon the field magnets, which could thus be made to revolve in place of the armature.

Fig. 3 is a diagrammatic representation of a ring-armature dynamo machine as a motor. The shaft is not shown. A is the core, B B is the "winding," which consists of the parts, b_1 b_1, which lie on the periphery, and which exert the driving force, and the parts, b_2 b_2, which serve to connect the driving bars or wires in the required manner. D D are connections made with the winding at intervals which terminate in segmental bars, C C, which form what is called the commutator, upon which the brushes, E + E −, rest. F + F − are the supply mains. Suppose the current to flow through the motor, as indicated by the arrows*; it traverses the brush, E +, and enters the armature through the commutator bar, C +, and its connection, D +; on reaching the winding it divides, one-half the total

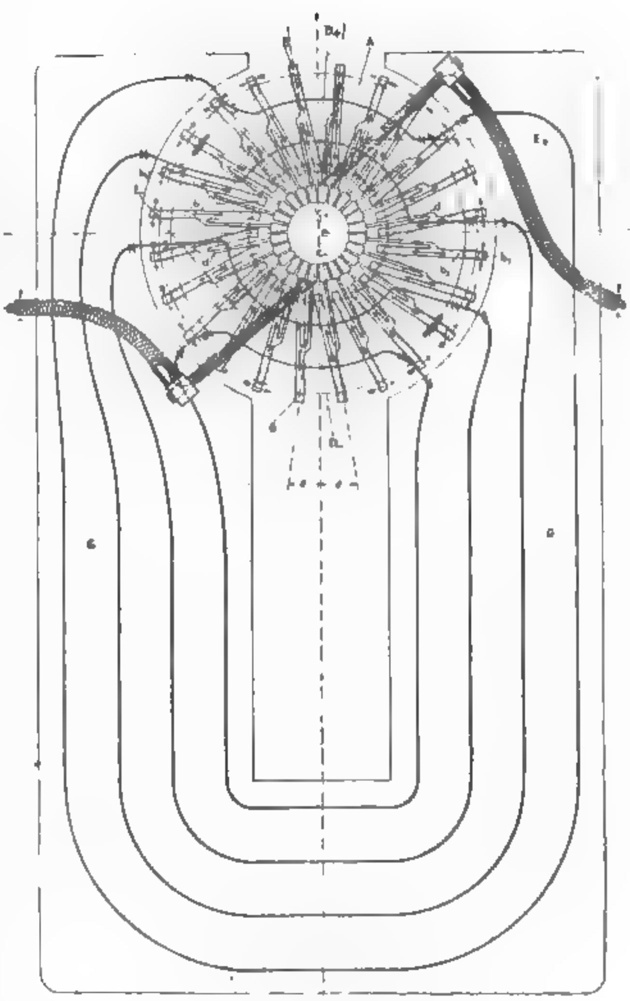


Fig. 3.

going each way round, until the two parts meet again at connection D −, whence the current flows out at E −. G G represent the massive electromagnet, between the curved polar surfaces of which and the armature core is the air space, or interpolar space, in which the conductors move, and where the intense magnetic field prevails when the field magnets are excited by the current through their exciting coils. The path of the magnetic flux is indicated by the lines which are marked with the letters N and S to indicate the direction of the flow. The magnetic flux flows from the mass of the magnet across the air space, through the laminated mass of iron, A, forming the armature core, across the second air space, back into the mass of the magnet, and round through the limbs and yoke

* In some forms of ring-armature machines the magnet poles are in juxtaposition to the sides, or even to the inside, in addition to, or instead of, the periphery of the armature. In these cases the wires or bars on these parts of the armature core also drive.

* I may here remark that the same quantity of electricity—the same current, we may say—leaves the motor as enters it, just as the same quantity of water flows away from a turbine as enters it. The electric current, whether it is merely the manifestation of molecular motion, or whether it is material in motion, is only the vehicle of energy. It does not disappear when it delivers up energy, any more than a driving rope or band does.

(as the end piece is called), so forming a continuous loop or circuit.

The direction of the current in the peripheral or driving wires or bars, is opposite over one-half of the armature to that over the other half; but it will be seen from the diagram, Fig. 3, that the direction of the magnetic field in which they lie is the same, therefore the force impressed by one-half of the driving bars is opposite in direction to that impressed over the other half, so that a rotational torque is applied to the core, and, through it and its mountings, to the shaft.

By means of the commutator, C, which revolves with the armature, while the brushes, E + E –, remain stationary, the direction of the current in the driving bars and their connections is reversed as the rotation proceeds, so that the direction of the current in all the bars which are in one air space is always opposite to the direction in the other air space.

This reversal is effected while the driving bars are passing through the two neutral or non-effective parts of their path between the poles of the large magnet, G, so the torque is quite constant, and a perfectly even and constant speed can be obtained, with an electric motor, without the use of a flywheel. The armature, it is true, has considerable inertia, but this is not called into requisition to maintain a constant torque upon the shaft, as is the flywheel of a steam engine.

The reversal of the current in the sections of the armature winding between any two commutator connections, D D, takes an appreciable time, owing to the phenomena of self-induction.* For this cause the manner in which the reversal of the armature sections is to be effected is one of the vital points to consider in designing an electric motor; almost, if not quite, as vital a point as is the reversal of the direction of motion of the connecting-rod and piston, etc., of a high-speed steam engine.

If this reversal is effected merely by the crank instead of by cushioning, and by giving "lead" to the slide-valve, so as to arrest and restart the piston, etc., and so effect the reversal of the motion, by the steam independently of the action of the crank, the engine will soon knock itself to pieces, though the fitting be never so perfect, and all slackness and play got rid of. There is a wonderfully perfect analogy between this problem in steam engine design, and that of effecting the reversal of the current in the armature sections of an electromotor.

If this is done merely by the make-and-break action of the brushes in sliding over the commutator sections, it is done, as it were, violently, and sparking and rapid destruction of both commutator and brushes is the result. Curiously enough, if certain factors have been duly regarded in the design of the machine, all that is necessary to do in order to get rid of the sparking is to give the brushes a "lead" (just as the engine slide-valve requires to have a "lead" over the crank), so that the reversal takes place a little to one side instead of just at the neutral point. The direction of lead is opposite to the direction of rotation in a machine running as a motor—in the direction of rotation in one running as a generator.

When the proper lead is given, the reversal takes place at a point found by trial when the armature section is in the fringe of the magnetic field through which it has just passed—*i.e.*, when it is leaving one of the air spaces (in the case of a motor). At this point the current in the section is brought to zero, and started in the opposite direction, to just the right strength by the back pressure (which we have seen is generated in the driving bars of a motor) independently, as it were, of the commutator. Thus the commutator and brushes must be designed and adjusted, not to cause the reversal of the sections by making and breaking the connection with the main, but so as to allow the reversal to be performed by the action of the magnetic field upon the section, and the winding and field magnets of the machine must be so proportioned and designed as to cause this reversal to be effected during the time that the commutator bars of the section are passing under the brushes.

(To be continued.)

* The phenomenon of self-induction in an electric circuit is analogous to that of inertia in mechanics. An electric current cannot be instantaneously started at a given strength, or instantaneously stopped after it has been started, any more than a body can be instantaneously started in motion at a given velocity, or instantaneously arrested after starting. The self-induction of a wire or conductor forming an electric circuit, however, is an extremely variable quantity, depending more upon the environment of the wire or conductor than upon the wire or conductor itself. The self-induction of an armature section varies in different parts of its path, but always has a high value due to the proximity of iron.

THE WESTON VOLTMETERS AND AMMETERS.

We in England are so accustomed to consider the manufacture of measuring instruments as peculiarly one of the home trades that we can hardly understand the threatened competition from American sources. Yet the Weston instruments, as shown at Frankfort, commended themselves to almost all who examined them, and although not so prominently exhibited at the Crystal Palace, the Mining and General Lamp Company have some of these instruments on show, as also cases in which the various parts of which the instruments are constructed are also exhibited. We understand, however, that some modifications have recently been made in the construction of the instruments, so that the latest types are not yet to be seen on this side. However, Dr. Maschke, in the *Electrical World* of New York, has described these instruments, and to his article we are principally indebted for the following information.

Introductory.—In no branch of modern engineering has the necessity of working under close control of accurate measurement been felt more urgently by those connected with the art than in electrical industries, and not many of nature's forms of energy are capable of being controlled and measured with a similar degree of perfection as the electric current. A great many forms of apparatus and methods have been devised for this purpose, and the degree of accuracy attained is an admirable proof of the wonderful progress of modern science.

There is, however, a great difference between the requirements of scientific work as carried out in laboratories furnished with all improvements and conveniences, and those of practical work, where the conditions of working are generally complicated by a large number of unfavourable circumstances, and where time saving is one of the most important items. It may fairly be said that, notwithstanding the astonishing amount of energy and ingenuity displayed in the invention and construction of electrical measuring instruments, almost all the forms of apparatus at present in daily use by the electrician are far from satisfying the practical requirements. In fact, the demand for improved apparatus is continually raised among electrical engineers and is constantly increasing.

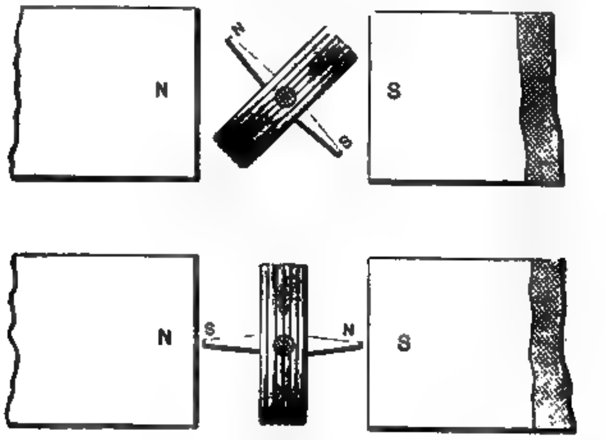
It is with the view of satisfying this demand that the Weston standard voltmeter and ammeter to be described below, for measuring E.M.F. and strength of current, have been designed. The general and high recognition with which these instruments have met since the day they were put into the market may be considered as a fair proof of their superiority over their competitors. They seem entitled to the claim that they answer the requirements of electrical practice more perfectly than any other instruments in use for the same purpose, especially as far as convenience, accuracy, and reliability are concerned, and it has frequently been acknowledged by competent authorities that they even surpass a great many forms of apparatus especially constructed for laboratory work.

Although everybody who has ever used the instruments will readily admit the great advantages offered by them, still they might be exposed to the objection made to all instruments in which permanent magnets are applied—viz., that the magnetism might not keep constant for any great length of time. Experiments to be described below will show how perfectly groundless this prejudice is, as far as the Weston instruments are concerned. It is sufficient here to state that with instruments continually in use for three years, no change of the readings could be noticed amounting to more than one-tenth of 1 per cent.

The object of the following articles is to give a brief description of the Weston instruments, and to follow this with a description of some of their more important applications. The descriptions will be such as will enable even those who are not familiar with the methods of electrical measurements to use the instruments for such measurements. An experienced electrician might see for himself what may be done with the instruments for other than voltage and current measurement, but he will be interested to learn what high degree of accuracy may be reached in certain measurements with this simple apparatus, which otherwise would require very complicated arrangements.

DESCRIPTION OF INSTRUMENTS.

Principle of the Apparatus.—If a flat coil of wire carrying an electric current is brought between the poles of a horseshoe magnet, it behaves exactly as if it were rigidly connected to a magnet fixed in its centre vertically to the plane of its windings. (*See* Fig. 1.)



FIGS. 1 and 2.—Principle of Apparatus.

Now, suppose the coil shown from above in Fig. 1 be suspended or pivoted so as to allow being rotated around its vertical axis, and let it be traversed by a current having the direction of the small arrow; it will then be turned in the direction of the larger arrow, from the position shown in Fig. 1 to that in Fig. 2. This rotation will be produced even by the smallest current, provided the coil is not acted upon by some opposing force. To make it a measuring instrument, therefore, requires that the tendency to turn be opposed by some counter force. Such a counter force is produced in the form of two flat, horizontal, spiral springs, fastened to the ends of the coil above and below it. When no current is flowing these springs will keep the coil in a certain zero position, from which it will be deflected the more the stronger a current which is sent through the coil. A pointer connected with the upper end of the axle of the coil, and moving over a properly graduated scale, will then indicate the position of the coil, and, therefore, the strength of the current to be measured. This is the principle of the Weston voltmeter and ammeter.

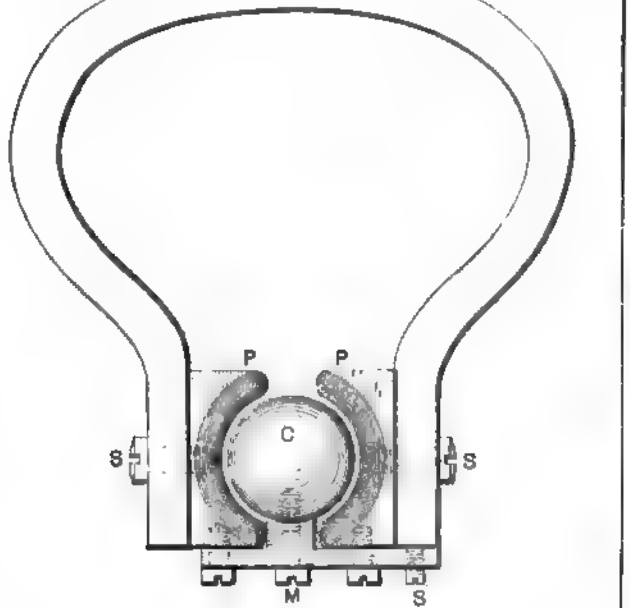


FIG. 3.—Magnetic Field.

The Magnetic Field.—The magnetic field is produced by the poles of a strong steel horseshoe magnet, Fig. 3, prepared by a special process. The cross-section of the same is a rectangle of about 1·25in. by 0·3in. Pole-pieces, P P, are attached to the inner surfaces of the poles and are fastened to them by screws, S S. The faces of these pole-pieces are of such a shape as to leave a perfectly cylindrical space between them. At the front side they are connected by two screws to a brass plate, M, carrying a massive soft iron cylinder, C, which occupies the larger part of the cylindrical space left by the pole-pieces. The dimensions of this cylinder are such that a small annular space is left between the cylinder and the pole-pieces, the width of which amounts to only 0·040in. in the most recent instruments. This space represents the magnetic field in which the coil rotates.

The Movable Coil.—The coil consists of fine insulated wire wound upon a light rectangular frame of aluminium. To avoid any assymmetry this frame is made by a special and ingenious process from a seamless aluminium tube. Including the coil, it has a thickness of 0·015in., so that its distance from the soft iron cylinder, C, on the one side and the pole-pieces, P P, on the other amounts to only 0·0125in., Fig. 4.

Fastened to each end of the coil is a pivot of hard polished steel, carrying a small brass collar, to which the inner end of a spiral spring is fastened. To avoid any interference from magnetic action the springs are not made of steel, but of some non-magnetic alloy. In a test made with one of these springs it was pulled out straight, and when allowed to recoil no change could be seen.

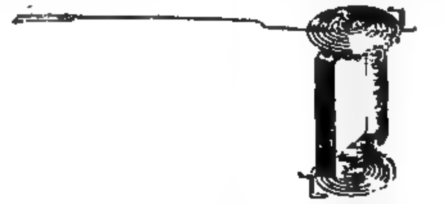


FIG. 4.—Movable Coil.

It goes without saying that the spring is not subjected to any permanent changes through long use of the instrument. The following reasoning will dispel any doubt as to the constancy of the springs. Suppose a good watch makes about 240 beats a minute, the swing of the balance being about 360deg., the number of contractions and expansions of the hairspring would amount to 1,382,600 per day. If we now assume that one of the instruments is used 300 days in the year, 100 readings being made every day, the deflections extending over the full scale length—that is, about 90deg.—it would require 46 years to do the same work with the spring of the instrument which a hairspring is doing daily. The slightest change in a hairspring would, of course, show this very distinctly during the course of a day, but we know by experience that we can rely upon a watch to a certainty for a much longer period.

Bearings of the Coil. Path of the Current.—Circular grooves are cut into the pole-pieces on their upper and lower surface, concentric with the cylindrical opening. Fitted into these grooves are the circular edges of two brass caps, as shown in Fig. 5, each of which carries in its centre a small sapphire forming the bearings for the pivots of the coil. By this arrangement the axle of the coil is made to accurately coincide with the axis of the soft iron cylinder.

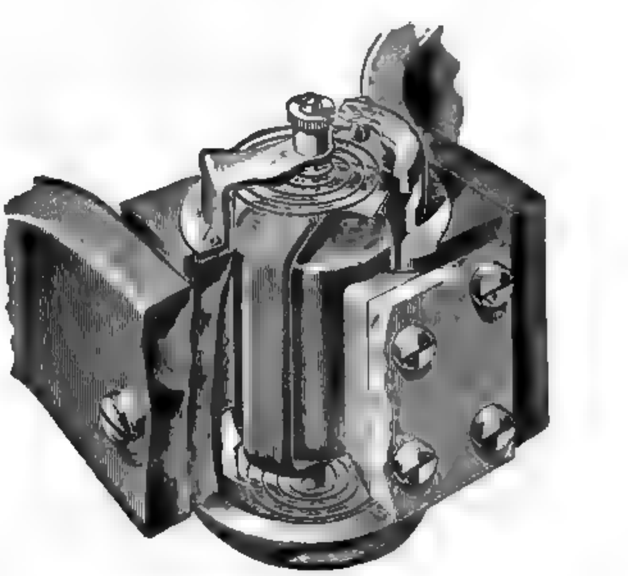


FIG. 5.—Bearings.

To each of these brass caps two diagonal arms of brass are fixed, which are insulated from the cap and can be moved around its centre. One of these arms acts as a support for the exterior end of the spiral spring which is connected therewith, while the other arm conducts the current to or from the respective spring. The current therefore passes from the lower brass arm to the lower spiral spring, thence through the coil to the upper spiral spring and to the brass arm connected with the upper cap.

Most of the voltmeters contain, besides the movable coil, a separate resistance coil located underneath the scale-plate and electrically connected between one of the brass arms and one of

the outside binding posts. In the ammeters the brass arms are connected directly with the terminals of a shunt contained within the instrument, Fig. 6.

Owing to the very great care used in the construction of the bearings, which are made with the same care and precision as in the best watches, friction is reduced to a minimum. To prevent the turns of the spiral spring from being pushed up beyond the end of the brass arm by an accidental violent motion of the apparatus, the arm is prolonged slightly in a horizontal direction beyond the point where the spring is fastened. A slit is cut into the cover, through which the spring can be seen, so as to make sure that all its turns are in one plane.

The Scale and Pointer.—The pointer of the apparatus is fixed to a small brass cross attached to the upper point near the bearing. The arms of the cross, by which the pointer is counterbalanced, are joined by a brass arc, into which a number of minute screws are inserted for making the fine adjustment to ensure accurate balancing. The pointer is made of aluminium, and is flattened at its end.

When the coil is in the zero position, the pointer, whose normal direction is perpendicular to the plane of windings of the coil, forms an angle of 45deg. with the middle line of the instrument. With the strongest current which is allowed to pass through the instrument, the pointer is deflected 90deg. from its zero position. Beyond these two extreme positions the coil is allowed only a small range, its motion being stopped by the two screws by which the iron core, C, is attached to the brass plate, M.

The scale is fastened to a brass plate, which is secured to the pole-pieces, projecting from them at right angles. Below the scale, quite close to it, a mirror is attached, to enable one to avoid making an error in the reading, due to parallax.

A slight raising or lowering of the scale may be effected by loosening one of the two screws, S_1 (Fig. 3) and by tightening the other one (in the figure only the upper one of the two screws can be seen). These screws do not enter into the poles of the magnet, but only press against them. The whole apparatus is mounted on a wooden baseboard and is covered with a brass case in which there are openings, provided with glass, enabling the scale and the point of the pointer to be seen.

Transportability.—For transportation it is placed in a wooden box or leather case, and may be carried in any position. Shaking or knocking, if not too violent, does not hurt the apparatus. Careful adjustment or levelling is not required, it being sufficient to place the instrument approximately horizontal. Owing to this fact, the apparatus is especially well adapted for use in street cars and on board ships. Violent shocks, though they will not change the magnetism of the magnet, might damage the pivots of the coil and thereby introduce the element of friction, which is avoided with such care in the construction of the apparatus. Figs. 7 and 8 show the instruments.

Readings.—The readings may be made immediately on applying the current. The pointer assumes it proper position by an instantaneous and dead-beat deflection. It indicates also the slightest momentary or permanent variations in the current or E.M.F. The dead-beat quality is due entirely to the damping effect which the frame of the coil experiences in moving through the strong magnetic field, the effect of friction in the bearings being practically nought owing to their careful construction and adjustment.

One of the most valuable features of the instrument is the uniformity of the scale, Fig 9. All scale readings begin at zero, and it is hardly possible to discover, with the naked eye, any difference in the spacing of any two neighbouring divisions. Each individual instrument is carefully calibrated for a large number of readings, and the scale drawn according to these calibrated readings. The divisions are drawn with extreme accuracy, and checked subsequently with the indications of a standard instrument.

Owing to the uniformity of the scale divisions, the fractions of a scale division may be estimated with great precision. As one-tenth of a scale division can be estimated easily, an apparatus ranging from 0 to 150 volts will allow reading to one-tenth of a volt. With the double scale voltmeters, the lower scale of which ranges from 0 to 5 volts, one three-hundredth of a volt may be read; and with the milli-voltmeters, the range of which extends from 0 to 0·01 volt on a scale divided into 100 divisions, readings may be taken which are accurate to one hundredth thousandth of a volt. The same degree of accuracy is attained in the ammeters.

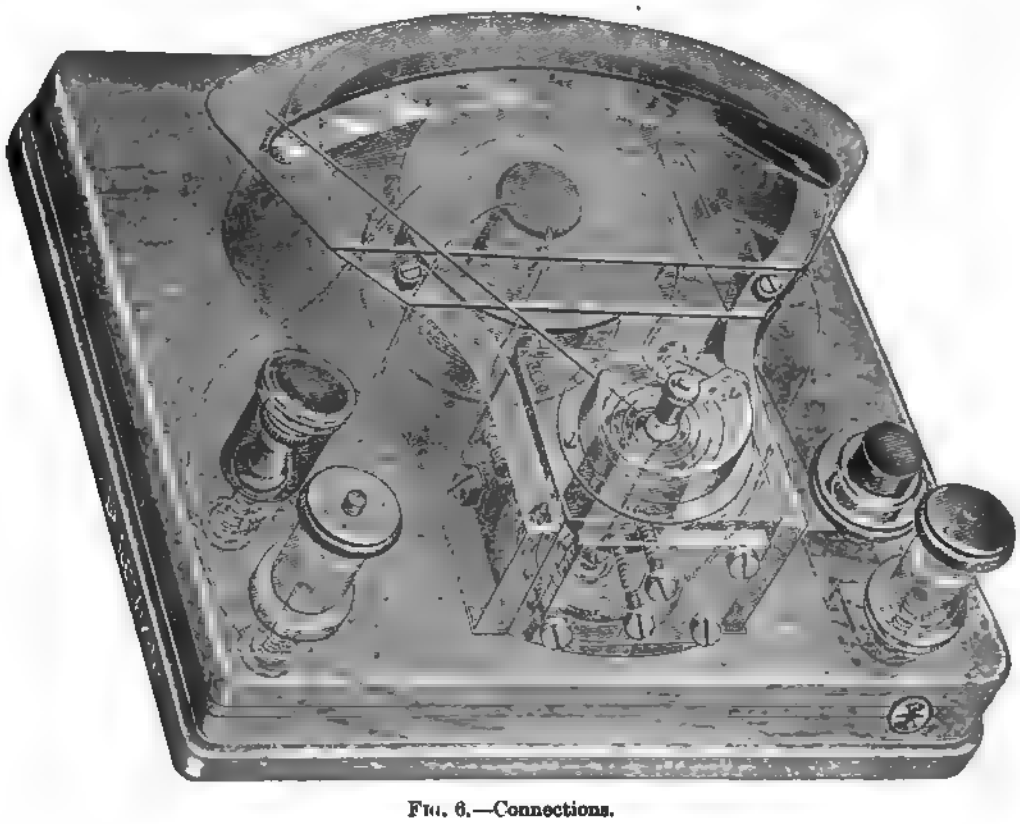


Fig. 6.—Connections.

Hysteresis.—In a great many other instruments containing soft iron, especially if the iron is in their movable parts, the indications obtained for the same amount of current are different, depending on whether the current was increasing or decreasing before the reading was taken. In the Weston apparatus this source of error is entirely avoided. There is no iron in the movable coil, and the immovable soft iron cylinder embraced by the pole-pieces is exposed to so strong a permanent magnetic field that the reaction of the minute currents of the coil cannot have the slightest effect upon it.

The Magnet and its Permanency.—It was stated in the introductory paragraph that practically no change of magnetism occurs in the Weston instruments. To what degree the constancy of the steel magnets used in the apparatus is maintained may be shown by a test, which hardly any other steel magnets so far manufactured would stand. The manufacture of magnets having such a degree of permanency means an important progress in practical electro-technics.

The following experiment will therefore be of interest not only as far as these instruments are concerned, but because it is a matter of general interest. The cover of a voltmeter was removed and the terminals connected with a circuit of the highest voltage allowable for that instrument, the pointer standing exactly over the 150th scale division. A magnet taken

from another similar voltmeter was then placed vertically upon the poles of the magnet of the instrument, the north pole of the one magnet being placed on the south pole of the other. The deflection of the pointer immediately went the horizontal one with similar poles together, and hammered as described. It may be remarked that every instrument is submitted to this test before leaving the factory, and is rejected if found not to stand it with perfect satisfaction.

FIG. 7.—Ammeter.

back to division 25. The top of the vertical magnet was then struck repeatedly with the wooden handle of some tool, as hard as the solidity of the apparatus would allow, which, as is well known, is about the best means of destroying the constancy of

As an additional test, the vertical magnet may be left standing upon the horizontal one for months; on removing it the indications of the instrument will be found as correct as in the experiment just explained above.

FIG. 8.—Voltmeter.

the power of a magnet. Notwithstanding this, upon removing the vertical magnet, the pointer immediately returned almost exactly to division 150. Although the experiment was

Although the magnetic field between the pole-pieces and iron core is very intense, the instrument is sensitive enough to show to the careful observer very small changes in the reading, if

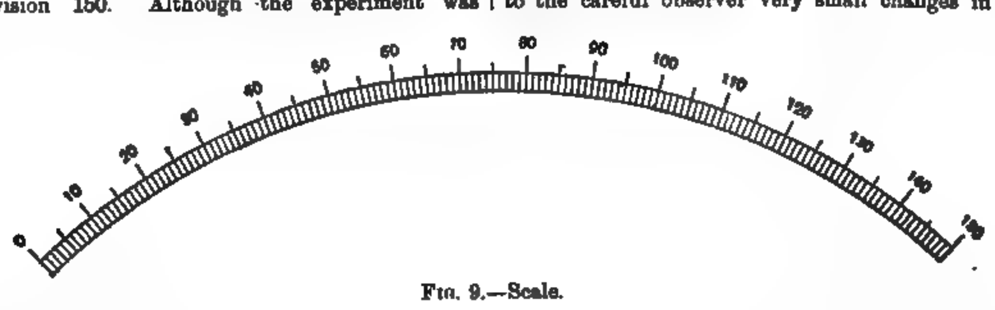


FIG. 9.—Scale.

repeated very often, the difference in reading caused thereby never exceeded one-half a scale division. The same favourable result was obtained when the vertical magnet was placed upon

the instrument is turned about its vertical axis, the E.M.F. or current to be measured remaining constant. These slight changes are due to the effect of external magnetic fields, such

as that of the earth. In calibrating the instruments proper precautions are taken in having them always in the same position in reference to the earth's magnetic north and south. The binding screw marked + in the voltmeters must always point toward the north and toward the observer, the observer facing west. In the ammeter the two binding screws on the right side of the instrument must be brought into the same position. This precaution is especially necessary if very accurate measurements are to be made. Influences of external magnetic fields may be avoided also by turning the instrument about its vertical axis, noting the maximum and minimum readings and taking the mean of the two readings obtained; this mean will be the correct result.

Influence of Temperature.—A very important point in electrical measuring instruments, particularly in voltmeters, is their dependence on changes of temperature, whether caused by variations outside of the apparatus or by the heat produced by the current within the apparatus itself. The latter point requires the most careful attention, especially in electric light plants, as the indications of the voltmeter become too low by the heating effect of the current, in consequence of which the engineer will be apt to raise the voltage of the dynamo, to the disadvantage of the lamps.

Careful tests of the Weston voltmeters have shown that a variation of 35deg. F. above or below 70deg. F. does not affect their readings more than one-fourth of 1 per cent. As far as the heating effect of the current within the instrument is concerned, it has been impossible to detect any variation of the readings with any voltages within the readings of the instrument—the changes due to increased resistance of the heated copper wire being counterbalanced by the changes taking place by the same cause in the other parts of the system. The voltmeter may therefore be inserted into the circuit for any length of time without sensibly affecting the accuracy of its indications.

In the Weston ammeters the independence of outside temperature is not maintained with so high a degree of perfection as in the voltmeter, still they also answer perfectly well in this respect all practical requirements. In these a change in temperature of 35deg. above or below 70deg. F. causes an error of 1 per cent. at the utmost; the readings exceed the true value by this small amount if the temperature rises as high as 105deg. and fall short of the true value by the same amount, at a temperature of 35deg. In regard to the heating effect of the current it may be added that changes keep within 1 per cent. for all ammeter ranges up to 150 amperes. Improvements being made now, with all probability, reduce this temperature considerably. In the highest range standard portable ammeters—viz., 200, 250, and 300 amperes—the heating effect of the current is somewhat higher. If, therefore, very high accuracy is required the instrument should not be kept in circuit for any length of time.

It might at first seem likely that the zero point of the apparatus could not remain constant on account of the expansion of the springs due to changes of temperature. This is avoided by a very simple device: the turns of the one spring run oppositely to those of the other, so that any expansion due to temperature is corrected completely, and therefore has no influence on the zero or the readings.

INSTITUTION OF ELECTRICAL ENGINEERS.

At the meeting of the Institution on the 9th inst., the discussion on Mr. Reckenzaun's paper on "Load Diagrams on Electric Tramways and the Cost of Electric Traction," was continued.

Mr. A. T. Snell had had some experience of tramway working in England, and considered that its success in the end was assured. Whether the final system would be an accumulator, conduit, or trolley one, he considered as yet uncertain. The accumulator car load diagram showed the current required by one car only, and there were numerous cases of no current when running down-hill or stopping, whereas the trolley diagram referred to several cars; and so the periods of no current were shorter, and there were less variations of current. The crux of the accumulator system lay in the accumulators themselves. On the Barking line there were four cars which ran 220 miles per day. Each car had three fresh sets of accumulators daily, and in bad weather four. The charging dynamo ran from 10 to 12 hours, and gave on an average 450 electrical horse-power hours per day. The energy given to the motors was not easy to determine, as the cells were sometimes run in series, and at other times in two parallels, depending on the number of passengers and the state of the roads. The drivers were always told to start in parallel, and not to work in series if it could be avoided. He estimated that the power averaged about one electrical horse-power hour per car mile, or 220 E.H.P. hours per day, an accumulator efficiency of about 50 per cent. On an average line he would put engine and dynamo efficiency at about 77 per cent., accumulators at 60 per cent., and motor, gearing, and starting device at 60 per cent.—a total efficiency of about 28 per cent. He preferred a single motor to two. There was sufficient adhesion on ordinary roads if the gradients were under 5 per cent. The combined efficiency with a two-motor car was about 5 per cent. less than with a single-motor one. Where there was a field for the former was on a line serving between a residential district and a town, the motors being run in series in the town and in parallel outside. With regard to gearing, he had no experience of gearless motors, but thought they would be best if the stoppages were not frequent. Double reduction had the advantage that the motor was lighter, as it could run at higher speed.

Mr. Blackwell had had considerable experience in America. The great mistake that pioneers there, as here, had made, was that they calculated the power required, and calculated it much too low. The practice of one road was no criterion of that on another; they varied so much both in gradients, state of the surface, and regularity of load. Their figures were often not comparable; the line which on paper appeared to be the most expensive often paying the best. The great difficulty in the last four years in America had been the gearing. All kinds had been tried, but he considered that single reduction held the field to-day. He was formerly much opposed to worm gearing, but was now partly converted, but would like to ask the author for some figures on the cost of working with various forms of gearing. As to cost, he knew of no case where horses had been replaced on a line by electric traction in which there had not been a great increase of profit. The number of passengers often rose 70 and 80 per cent. With regard to Mr. Manville's remarks about interference with the telephones he quite agreed with them. In America the telephone companies tried to get over the induction by using double wires, but found them a great nuisance.

Mr. Condict agreed that there would be a great advantage in the use of accumulators at the station as steadiers. He believed in the author's plan of dividing up the field magnets into sections for varying the power, and had gone further in America, where they sometimes used a double armature with a commutator at each end, the two being used either in series or parallel. He had obtained very good results with worm gearing, and had made some tests in which it came out very well compared to both single and double reduction gear. To the latter he was strongly opposed on account of its noisiness. With regard to the weight of his cars, he would put car, battery, and motor at 5,000lb. each, and 80 passengers at 12,000lb.

Mr. Jarman believed strongly in the accumulator system, especially as they could be put on any ordinary line with horse cars without altering the track. The present horse lines might be divided into two classes—those that paid and those that did not. The former did not want to change to power, and the latter could not afford to. In his own work they often ran gradients of 1 in 16 with 68 passengers on a 44-passenger car. Accumulators now gave them but little trouble, but he was careful not to take larger currents from them than he could help. He preferred two motors to one, and always used them in series when possible. In reply to a question from the President, he could not give the cost per car mile, including cost of renewals, but proposed to read a paper on the whole subject at a future date. His cells had been running two years without renewals.

Mr. Sellon objected to the author saying that the expenses of the Blackpool line were 67 per cent. of the gross receipts. There was some £873 to be deducted for part of rent paid to the town, and other items, and this brought the figure down to 4·31 per cent. Two of the winter months, also, they were running at a loss. Taking from April to September only, the cost was £1,524, and the receipts were £5,570, giving 27 per cent. With regard to accumulator traction, he believed one set had run 4,000 miles, with 785 discharges, and no renewals.

Mr. Crompton said that the reason cells did not last was that the outer surface of the active material was always being jarred off. The right direction to work in was to try and get some non-pasted cell and also to improve the springs of the cars. In crowded cities he thought the accumulator system was the only feasible one.

Mr Trotter said the diagrams really depended as much on mechanical details as on electrical ones. Much could be learnt from both accumlator and transmission diagrams—as to the effect that a heavy flywheel on the engine would have. For integrating the curves to find the total amount of power, he drew them on the oiled paper used in copying letters and then cut them out and weighed them, knowing the weight per square inch of the paper, which was very uniform. For a rough test the curve when cut out could be balanced on a pencil to find the height of the line of average current.

Mr. Williams said the mean current appeared only to be 30 per cent. of the maximum, which was a very wasteful arrangement. Americans rather objected to using compound engines, on the ground that they were not economical at low loads. This, however, was not correct. It was true, however, that a compound had to be larger than a simple engine, as in the former steam would not be admitted during the whole stroke, as it could in a single engine on emergency. Mr. Baker had brought a dynamo with him from America with a 10-ton flywheel, and he thought a good deal was to be done in storage by that means. He agreed with a previous speaker that it would be well to start the motor free, and bring it into gear by a friction clutch, as it should save a great deal of loss in the leads, and the inertia would help the starting instead of opposing it, at is did when starting from rest.

Mr. Swinburne wished to know why such large horse-power was required—30 h.p. motors on a car usually drawn by two horses. Mr. Field had told him he was running a car with a 2-h.p. motor coupled direct through rods, thus avoiding gearing loss.

Mr. Fraser said there was no need to use much power to start a car if you only did it slowly enough. The starting current at

Barking, with all resistance in, was 40 amperes, and the running current about 30 amperes, the maximum being 70 amperes for 200 yards on a steep gradient. The voltage was 100.

Mr. Reckenzaun, in reply, said, with regard to the Southwark railway, it was running under different conditions to a tram line—being worked by signals, it could be arranged that two trains should not start at once. He thought that if Mr. Baker had added a competent English engineer to his staff of American ones, he would have saved much of his preliminary expense. He spoke of the engine at Roundhay working much under power—its average output was certainly only 75 h.p.; but a maximum of 165 h.p. being sometimes required, the engine could not well have been much smaller. With regard to starting the motor light, and then throwing it into gear, he had tried this nine years ago and found it quite useless; even when there was a 120lb. flywheel on the motor it was pulled up before the car started. The 17-ton car mentioned by Mr. Russell he thought a very excessive weight. The ordinary American cars, with passengers, weighed about nine tons. Two motors he considered much better than one, and American practice confirmed this view; mechanical coupling of the two sets of wheels he thought bad, as it produced so much friction. He quite agreed with Mr. Crompton's remarks on batteries. He could not quite understand the line which Mr. Swinburne spoke of as being said to run with 2 h.p.; he himself had begun with one 4-h.p. motor, but it would not do. The Americans now use two 15-h.p. motors. If one breaks down, the other will run the car; and the two together are wanted when a car leaves the rails. The pull required to start a car he had found from several tests was from 100lb. to 200lb. per ton.

BATH.

At the meeting of the Surveying Committee of the Bath Town Council last week **Mr. Sturgess** proposed the adoption of the following report from the Electric Light Sub-Committee:

"1. Your sub-committee have held nine meetings since their report to you of the 5th September last.

"2. The three additional arc lamps recommended in the report have been placed on the spots indicated and give satisfaction to the parties resident in the respective neighbourhoods.

"3. The duties of the inspector appointed under the license rendered it necessary that he should be provided with certain instruments to be under his sole control irrespective of the instruments provided by the company, and your committee, after a correspondence with the Board of Trade, and in pursuance of their opinion on the subject, have provided him with these instruments at a cost of £25. 2s. 5d.

"4. The inspector, on the 4th November last, made an exhaustive report to the committee upon the subject of the arc lamps, in which he stated that the public arc lamps used in the Bath electric lighting system are properly described as 1,200 c.p., although they do not give an effective candle-power of 1,200 candles as used in the streets surrounded with ground glass or opal globes. From many tests made by the inspector, he found them all concurring that the ground-glass globes, when clean, absorb from 42 to 46 per cent. of the light emitted from the carbon at any given angle, and the opal globes from 54 to 70 per cent. of the light, and absorb a larger percentage of light when not properly cleaned. As it appeared that the light transmitted depends upon the globe used and the state of the globe, your inspector was directed to devote particular attention to ascertain what improved globe could be recommended for use, and also to suggest a plan by which the globes might be more thoroughly cleaned. On an interview with your committee, and after testing several globes of recent manufacture, he found that the Pearline globe, manufactured by Messrs. Rollox and Co., of 47, Holborn-viaduct, allowed the greatest emission of light, and that the light emitted through that globe was 30 per cent., or nearly one-third more than the light emitted through the globes now in use by the company. He also recommended that the globes should be periodically cleansed with caustic soda, as unless kept thoroughly clean a large portion of the light emitted from the carbon is absorbed. These suggestions have been submitted to the company, and to a large extent complied with by it.

"5. As the period for which your inspector was appointed has now elapsed, your committee recommended that he be again appointed as inspector under the license for another term of six months, with the same duties, and at the same scale of remuneration as in his former appointment.

"6. The testings of 'power' have, as yet, been made by the inspector at the company's central station. As the committee have not yet been able to settle a convenient place for an independent testing station, the matter is still under their consideration.

"7. The committee have considered the charges of £54 made by the inspector for his services during the period of his appointment, and find them in accordance with the schedule of charges authorised by the authority, and recommend them for payment."

Mr. Gatehouse presented a supplemental report in which he stated: "During the past six months two partial failures of the electric light had occurred. The weak points in the installation were evidently at the bottom and top of the lampposts where the leads are in close contact and not protected by the bituminous insulation which exists underground. For the past month the insulation resistance of both circuits had been much improved. Four lamps only on both circuits had partially failed during this time, and these were burning till 4 or 5 a.m. In order to more conveniently test both arc lamps and circuits the company had recently put up a new testing-room at the works, which, when completed, would afford greater testing facilities. The directors had within the last week applied to him under Section 46 of the Electric Lighting Act to test and register the meters they intend to supply to all their customers. For that purpose he should require to be furnished from the mains with the current in which it was supplied to the consumer. It would be necessary to be connected with the mains through the medium of a transformer, so as to enable him to obtain the current for the registration of the meters under proper conditions."

In answer to **Mr. Taylor, Mr. Bartrum** said the question of having the inspector's office supplied with the light, so that he might test it there, had been considered, and the only point to be considered was who should bear the expense—the Corporation or the company.

The reports were adopted.

COMPANIES' REPORTS.

ORIENTAL TELEPHONE COMPANY.

Directors: William Addison, chairman; B. St. John Ackers, Henry Grewing, Thomas Lloyd, George Bland Frost. Secretary: Alexander B. Chalmers.

Report of the Directors for the year ending December 31, 1891, to be presented at the twelfth ordinary general meeting of the Company to be held at the Cannon-street Hotel on Wednesday, the 27th inst., at 1 p.m.

The Directors beg to submit to the shareholders their usual annual statement of accounts for the year ending 31st December, 1891. The revenue account for the year shows a balance to credit of £8,918. 13s. 10d., which has been transferred to profit and loss, and including £2,250. 19s. 9d. brought forward from the previous year, a balance remains for disposal of £11,169. 13s. 7d. The Directors propose to deal with this as follows: To write off £257. 0s. 4d. legal and other expenses caused by the action brought by holders of vendors' shares; £1,466. 4s. 8d. in reduction of capital expenditure; to add £3,000 to reserve fund, which will then stand at £10,000; and to pay a dividend of 2¼ per cent. free of income tax on the total paid-up capital of the Company, carrying forward £1,957. 16s. 4d. As the shareholders are aware, a large portion of the earnings of the Company are in silver currency; and, owing to the low exchanges which have lately been ruling, the profit of the year has been somewhat diminished. As mentioned in the report of last annual general meeting, a copy of which was sent to each shareholder, proceedings were taken by a holder of vendors' shares to restrain the Directors from distributing the profits of the Company in the manner indicated in the last annual report and accounts. The Court having upheld the action of the Directors, the distribution for the past year will be made in the same manner, the 2¼ per cent on the entire paid-up capital of the Company being equivalent to £3. 12s. 2d. per cent. on each ordinary share of 11s. paid, issued prior to the 4th February, 1886. The Indian companies continue to improve. The Bengal Company has been able to increase its dividend by ½ per cent., the distribution for 1891 being 5½ per cent., whilst the Bombay Company has declared a dividend equal to that of the preceding year—viz. 4 per cent., transferring Rs. 10,000 to its reserve and depreciation fund. The Bengal Company already possesses a reserve fund in cash of Rs. 50,000. The Telephone Company of Egypt, after payment of debenture interest, has declared its usual dividend of 6 per cent. on the preferred shares, carrying forward £1,414. 17s. The China and Japan Telephone Company's accounts for 1890 closed with a surplus of £841. 12s. 5d., as against £573. 16s. 4d. for the previous year. The accounts for the past year are now in course of preparation. The branches worked directly by the Company maintain their revenues and in one or two instances show slightly improved results. The shareholders will remember that last year they approved a resolution to alter the Company's memorandum of association so as to embrace "any business or manufacture relating to the generation, employment, or utilisation of electricity or magnetism, or the apparatus connected therewith." This resolution having been duly confirmed, application was made to the Court for permission to amend the Company's memorandum accordingly. The application was after consideration sanctioned, but the Court suggested that as the power of extension of business was considerable, the name of the Company should be altered, and expressed approval of its being changed to the "Oriental Telephone and Electric Company, Limited." The Directors see no objection to such alteration, and the resolution mentioned in the notice on the back hereof will therefore be submitted for the consideration of the meeting. The Directors to retire at the present meeting are Messrs. Henry Grewing and William Addison, both of whom being eligible, offer themselves for re-election. The auditors of the Company, Messrs. Deloitte, Dever, Griffiths and Co., also retire, and offer themselves for re-election.

City and South London Railway.—The receipts for the week ending 10th April were £742, against £830 for the corresponding period of last year, showing a decrease of £88. The total receipts to date from January 1, 1892, however, showed an increase of £1,169.

NEW COMPANIES REGISTERED.

Madras Electric Tramways Company, Limited.—Registered by Paul E. Vanderpump and Eve, 5, Philpot-lane, E.C., with a capital of £100,000 in £1 shares. Object: the acquisition of certain concessions granted by the Madras municipal authorities, November 18, 1891, and approved by the Madras Government in accordance with the provisions of the Indian Tramways Act, 1886, for the construction of tramways in Madras, in accordance with an agreement, made March 16, between W. Digby and S. A. Chalk, of the one part, and F. W. Fowles, on behalf of this Company, of the other part, to carry out the construction of the said tramways, and to work the same by animal power, electricity, or otherwise. The first subscribers are:

	Shares.
W. Digby, 1, Trafalgar-buildings, Northumberland-avenue, S.W.	1
A. J. Lusty, 70, Gracechurch-street, E.C.	1
S. A. Chalk, 1, Trafalgar-buildings	1
A. E. Asser, Suffolk Lodge, Teddington	1
M. M. Bhownaggree, Tessville, Bedford-park	1
W. A. Gibson, 4, Queen Victoria-street, E.C.	1
H. E. Eve, 5, Philpot-lane, E.C.	1

There shall not be less than three nor more than six directors. The first are W. Digby (chairman), M. M. Bhownaggree, W. A. Gibson, A. J. Lusty, and S. A. Chalk (managing director). Qualification, £250. Remuneration: W. Digby, £650 per annum; S. A. Chalk, £400 per annum; other directors, £100 per annum.

BUSINESS NOTES.

Submarine Cables Trust.—It is announced that a payment of £1. 2s. 6d. will be made on account of the coupon, due on April 15, on the 16th inst. by Messrs. Glyn, Mills, Currie, and Co.

St. James's Electric Light Company.—The value of the current sold by the Company during the quarter ending March 31 last amounted to £10,024, as against £9,652 for the corresponding period of last year.

The Direct United States Cable Company have declared an interim dividend of 3s. 6d. per share, tax free, being at the rate of 3½ per cent. per annum, for the quarter ending March 31, 1892, payable on and after 23rd inst.

Manitoba Electric and Gas Light Company.—At an extraordinary meeting of the debenture holders of this Company held at 31, Lombard-street, on Monday, Mr. L. R. C. Boyle, one of the trustees of the debenture holders, formally resigned his post.

Electric Construction Corporation.—At a recent extraordinary general meeting of the Corporation, the resolution passed at the meeting on the 22nd ult., authorising the Directors to allot half of the new issue of shares as preference shares, entitling the holders to a cumulative dividend at the rate of 7 per cent. per annum in priority to any dividend on the ordinary and founders' shares, and further entitling the holders, upon a return of capital of the Company, to be repaid the amounts credited as paid on their shares before any payment in respect of capital on the ordinary and founders' shares, was confirmed.

Indo-European Telegraph Company.—The report of the Directors for 1891 shows that the revenue from all sources amounted to £116,699, as compared with £113,807. Deducting the expenses, taking credit for £4,168 brought over from 1890, and debiting income tax, there remains £58,483, from which £10,090 has been placed to reserve, and that sum, together with £10,625, the amount of interim dividend, have to be deducted, leaving £37,858. The Directors propose a dividend for the six months ending December 31 of 17s. 6d. per share, making 6 per cent. for the year, and a bonus of 20s. per share, both tax free, making in all 10 per cent., carrying forward £5,983.

PROVISIONAL PATENTS, 1892.

April 4.

6465. **Improvements in electrical secondary or storage batteries.** George Eduard Heyl, 11, Furnival-street, Holborn, London.

6467. **Manufacture of the alkaline carbonates or bicarbonates by the electrolytic decomposition of alkaline chlorides in the presence of gelatinous alumina or chloride or other salt of aluminium.** Eugène Hermite and André Dubosc, 28, Southampton-buildings, Chancery-lane, London.

April 5.

6551. **Improvements in electric recording devices for mariners' compasses and other instruments.** Charles Ludwig Jaeger, 23, Southampton-buildings, Chancery-lane, London. (Complete specification.)

6569. **Improvements in telephone cables.** John Edward Kingsbury, 24, Southampton-buildings, Chancery-lane, London. (The Western Electric Company, United States.) (Complete specification.)

6579. **Improvements in alternate-current electromotors.** Max *Déri, 28, Southampton*-buildings, Chancery-lane, London.

April 6.

6629. **Telephone call apparatus.** Siemens Bros. and Co., Limited, and Frank Jacob, 28, Southampton-buildings, Chancery-lane, London.

6635. **Improvements in or connected with moulds for casting ribbed metallic plates, more especially intended for use for casting plates for secondary batteries.** Anthony Spencer Bower, 47, Lincoln's-inn-fields, London.

6637. **Improvements in electrodes for storage batteries.** George Eduard Heyl, 11, Furnival-street, Holborn, London.

April 7.

6694. **Improvements in electric hair and skin brushes.** George Ive Spalding and Richard Leonard Hawkins, 34, Southampton-buildings, Chancery-lane, London.

6698. **Improvements in and relating to dynamo-electric machines, electric motors, continuous-current transformers, and the like.** Herbert Glenn Jackson, 70, Chancery-lane, London.

6707. **Improvements in the method and apparatus for registering supply of electricity.** Gisbert Kapp, 46, Lincoln's-inn-fields, London.

6720. **Improvements in dynamo-electric machines.** John Augustine Kingdon, 29, Marlborough-hill, St. John's Wood, London.

6722. **Improvements in battery plates or secondary batteries.** William Walter Donaldson and Roderick Macrae, 22, Southampton-buildings, Chancery-lane, London. (Complete specification.)

April 8.

6725. **The manufacture of electrical fires.** George Edward Tucker, 9, Duke-street Mansions, Grosvenor-square, London.

6726. **Improvements in multiple switchboards for telephone exchanges.** Robert Pippette, 31, Endymion-road, Brixton-hill, London.

6775. **A new or improved electrical apparatus.** Thomas Higginson-Wolstencroft, 37, Chancery-lane, London.

6785. **Improvements in electrically controlling the levers of railway signal interlocking apparatus.** Leicester Bradney Stevens and William Robert Sykes, 40, Chancery-lane, London.

April 9.

6861. **Improvements in electrical heating apparatus.** Gustav Binswanger, 28, Southampton-buildings, Chancery-lane, London.

6868. **Improvements in dynamos or motors.** Ralston Carrington Kintzing, Monument-chambers, King William-street, London.

6870. **Holding telephone receivers—viz., that part of a telephone through which the communication is heard—against the ear.** Arthur Daniel Monies, 16, Daulby-street, Liverpool.

SPECIFICATIONS PUBLISHED.

1886.

13341. **Covering, etc., electric wires.** Newton. (McCracken.) (Second edition.)

1891.

4794. **Signalling and telephonic systems.** Kingsbury. (Western Electric Company.)

5338. **Electric arc lamps.** Crampton and Essinger.

5989. **Electric lighting.** Lancaster.

6633. **Electric meters.** Teague.

8378. **Electric current circuits.** South.

8450. **Connecting electrical conductors to surgical, etc., instruments.** Snell.

18290. **Electric switches.** Lundberg.

22352. **Electric switches.** Painter.

22782. **Electric arc lamps.** Fricker.

1892.

2254. **Incandescent electric lamps.** Thompson. (Fuss.)

2329. **Bleaching by electrolysis.** Imray. (Montgomery.)

2458. **Dynamo-electric generators, etc.** Poole and others.

2913. **Electro-metallurgic extraction of zinc.** Nahnsen.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5¾
Metropolitan Electric Supply	—	8¾
London Electric Supply	5	1½
Swan United	3½	4¼
St. James'	—	8¾
National Telephone	5	4½
Electric Construction	10	6¼
Westminster Electric	—	6¾
Liverpool Electric Supply	5	[illegible]
	3	3

NOTES.

Belgium has now 35 telephone exchanges.

Personal.—Prof. Geo. Forbes is on a professional visit to America.

Marseilles.—At the trial of the electric railway at Marseilles, a wire broke and killed a horse, besides burning several persons.

Brighton. — The Local Government Board have sanctioned the loan of £8,500 to the Brighton Corporation for electric lighting.

Haslingden.—The Haslingden town clerk has been requested to obtain all possible information with respect to the Electric Lighting Act.

Institution.—On Thursday next a paper will be read before the Institution, "Notes on the Light of the Electric Arc," by A. P. Trotter, B.A., member.

Naples.—It is announced that an electric railway is to be constructed between Naples and Alfedena, the power being obtained from the falls of the Volturno.

Neubad.—The central station of Neubad has made a profit of £16,270 for last year, and has paid a dividend of 5 per cent. Current is supplied representing 22,500 lamps of 16 c.p.

St. Petersburg.—On Easter Day the electric light went out suddenly when service was being held in the Winter Palace, and a beam was found to be in a blaze. The fire caused little damage.

Phonoporic Telephony.—In the article from the *Times* on the phonopore, it should have been stated that the contract pending is with the Great Western, not the Great Northern Railway Company.

Deputations.—A deputation from the Harrogate Town Council visited the Crystal Palace on Wednesday last week. The Electric Lighting Committee of the St. Pancras Vestry visited the Palace on the same day.

Australia. — The Rockhampton Municipality has accepted the tender of a Sydney firm of electricians to supply the township with electric light. The installation is to be completed by the end of July.

Cost of Electric Lighting.—A merchant in Bradford gives the following as the cost of electric lamps in his warehouse at Bradford: 200-c.p., 4d. per hour; 100-c.p., 2½d. per hour; 16-c.p. lamps, 4d. each per 14 hours.

Huddersfield.—The station proposed for Huddersfield has provision for 6,600 8-c.p. lamps. Babcock boilers are to be used. We wonder if the woollen manufacturers would use these if a new factory were to be erected.

Barnsley.—The Lighting Committee of the Barnsley Town Council intend to visit the electric light works at Bradford on Monday, and after this visit a decision as to the introduction of electric lighting into Barnsley will be made.

Azores Cable.—A Dalziel's telegram from Lisbon says it is almost certain that the concession for laying the Azores cable will be granted to a French company. Thus France will control both this and the cable connecting France and Portugal.

Taunton.—Mr. Gisbert Kapp has been appointed to visit the electric light station at Taunton, to report upon and value the works on behalf of the Corporation. A special meeting on the purchase of the works is to be held on May 3.

Electric Launches.—Bids have been received for the running of electric launches on the lakes at the World's Fair, and it is understood that the Electric Launch Navigation Company, of New York, offer to pay over one-third of the total receipts.

Poland.—The municipality of Murich-Ostran, Poland, is discussing tenders for the establishment of an electric railway between this town and those of Prziwos and Witkowitz. A central station for supplying light and power is to be established at the same time.

Tunstall.—The Tunstall Local Board have intimated to the Electric Trust, who have a provisional order, and are wishing to extend the time, that if they will undertake to supply light within six months, the application will be supported, but otherwise it will be opposed.

Chicago Exhibition.—It was stated a few weeks ago that Messrs. Siemens and Halske intended making an immense exhibit at the World's Fair. It is now understood that, owing to difficulties in obtaining the space required, they have given up the intention to exhibit.

Carmarthen Asylum.—The Carmarthen Joint Committees have had before them the question of lighting the institution by electricity, instead of by gas as at present, and it was decided to ask Mr. Howell, electrician, Llanelly, to report upon the matter at the next meeting of the committee, to be held in June.

Arc Lamps at Chicago.—The World's Fair Company will pay 20dols. per lamp for 5,000 to 6,000 arc lamps required for electric lighting. About 100,000 incandescent lamps will also be used, but are not yet contracted for. It is expected, we believe, that some of the electric lighting will be given to English contractors.

Asbestos Porcelain.—M. F. Garros has communicated to the Academie des Sciences the result of experiments made at the Central Electrical Laboratory on the conductivity of asbestos porcelain employed as porous cell of batteries. He finds that the resistance of ordinary is 2·75 higher than that of the asbestos porcelain.

French Physical Society.—The annual exhibition of the Société Française de Physique has been held this week. A large number of interesting experiments were arranged, the principal interest being accorded to the repetition of Mr. Tesla's experiments by M. D'Arsonval. A considerable number of novel instruments were also exhibited.

Electric Welding.—A patent has been issued in America to the Thomson-Houston Welding Company for electrically working metals by means of the arc, upon the process invented by Augustus de Menteres, of Paris. The United States Patent Office has definitely decided in the favour of this patent after prolonged interference proceedings by Benardos and Olszewski.

The Snowstorm.—A violent snowstorm astonished everybody last Saturday. Very great damage was done to telegraph wires—that to the lines between Dover and London being stated as unprecedented. Even on Wednesday only one main line wire was restored. On the top of Reigate Hill the snow was drifted on the banks over 6ft. high, an extraordinary sight in the middle of April.

Bray.—The lighting of the town of Bray is being rapidly pushed forward by Messrs. J. E. H. Gordon and Co. A lease of Bray Mills has been acquired, and the dynamos will be driven by water power, but steam plant for 100 h.p. will also be installed. The lighting will be both public and private, the streets being lighted by arc lamps. The alternating system with transformers is used.

Ludlow.—At the last meeting of the Ludlow Town Council a letter was received from the British Electric Installation Contractors, Limited, asking the permission of the Corporation to a company laying underground and overhead cables for the supply of electricity in the borough. After some discussion Mr. Weyman considered they were

asked to give powers to a company which did not exist, and the matter was left over.

Coast Communication.—A meeting is to be held at the Mansion House, London, next Tuesday, under the auspices of the National Sea Fisheries Protection Association, in support of the resolution to be moved on the following evening in the House of Commons by Sir Edward Birkbeck, urging the Government to take steps to establish electric communication between lightships, lighthouses, and the shore, for the saving of life and property at sea.

Madras Electric Tramway.—The prospectus of the Madras Electric Tramway Company, Limited, has been issued. Mr. Codd, the company's secretary, we learn from the *Indian Engineer*, has left for Bombay, whence he proceeds to England. Up to date only one objection has been lodged with the Madras Government, this being from the Telegraph Department, who fear induction will result from the proximity of the company's wires to the telegraph wires.

British Grant for World's Fair.—The Government having increased to £60,000 the grant of £25,000 originally made for the purposes of the British Section at the Chicago Exhibition, the Royal Commission for that exhibition are enabled to dispense with the revenue it was proposed to raise by charging the exhibitors in proportion to the extent of space occupied, and that therefore all space in the British Section will now be granted free of charge.

Coatbridge. — At the Coatbridge Town Council meeting last week, Provost Alexander stated that the Scottish House-to-House Electric Lighting Company had approached the committee on the electric lighting of the municipal buildings with a view to getting a company formed to light the whole town, but he had left it over to see if a majority of the Council favoured the scheme. The proposal was favourably entertained, and the committee, with the Provost added, was instructed to get the fullest information and report to the members of the Council.

Railway Station Lighting.—A complete electric plant is being erected in Lime-street Station, Liverpool. It is intended to light the whole of the station and offices and the rooms in the hotel by electricity. The hotel is already partially supplied with the electric light, but when the new plant is ready the system will be extended throughout the building, including the new wing now being built. The Midland Railway Company are also about to introduce the electric light into all their offices at Derby, and also at the Midland Hotel. The installation will cost about £11,000.

Pamphlet on Coast Communication. — The Plymouth Chamber of Commerce has printed and circulated amongst members a valuable pamphlet on "Electrical Communication on the Coasts of the United Kingdom." It is pointed out that the Post Office could carry out the extension with ease. Watch is kept on the coastguard stations; a staff of men exists. Nothing is wanted but an outlay on instruments and telephones between the various stations and the nearest telegraph lines. The case put by the Plymouth Chamber of Commerce seems unanswerably strong.

Telegraph Rates to Australia.—In reply to Mr. Henniker Heaton on Monday, the Postmaster-General said the reduced rates to Australia and Tasmania are about 4s. a word. To Queensland and New Zealand they remain at about 10s. a word. The reduction is brought about by the loss entailed being borne jointly by the Governments concerned and the Eastern and Eastern Extension Companies. To India the charge is 4s.; there was no intention of proposing a similar reduction and guarantee to India; the commercial relations, he thought, would not allow sufficient increased business.

Southport.—The Mayor of Southport, speaking at the christening of the "Bonnie Southport" electric launch, said the launching of the boat was the first introduction of electricity into Southport by the Corporation, but before the end of the year he hoped to see electricity illuminating all the public buildings, the principal streets, and many private houses. This launch was constructed by Messrs. Woodhouse and Rawson at their Chiswick works. It will seat 40 persons, is 38ft. 5in. long and 7ft. 6in. beam, and draws 2ft. 3in. of water. It is built of bright mahogany, and is propelled by a 5-h.p. motor. It was running at Easter with much success.

Cologne.—A central station was started in Cologne on the 1st October last year, with a starting load of 1,000 16-c.p. lamps. The output has very rapidly increased, until at present there are over 13,000 lamps supplied. The present station is capable of supplying up to 30,000 lights. The station is owned by the municipality, and is interesting from the fact that the plant is arranged so that the reservoir pumps are driven from the same engine. The total steam power is thus now kept practically constant from one year's end to the other, as during the summer months, when the lights are fewer, the amount of water to be pumped to the reservoirs is increased.

Electricity in Paper-Making. — A lecture was recently given on the application of electricity to paper-making by Mr. E. J. Beavan, of Messrs. Cross and Beavan, chemists, London, in the Society of Arts Hall, Edinburgh, to the Scottish Papermakers' Association. The object of the lecture was to show the comparative cheapness of the electrical process in the manufacture of the products used by the paper manufacturer for bleaching purposes, and Mr. Beavan entered into calculations to show that, with plant driven by an engine of 2,400 h.p., the manufacturer could produce, at a daily cost of £133, chemicals which at present cost him £300.

Exeter.—At the meeting of the Exeter Town Council last week, the resolution by Councillor Perry, that the surveyor should prepare a report upon the lighting of the city, was carried. The problem before the Council was whether the lighting cost should be raised from £600 to £1,400 with a gain of 16 times the light. The Mayor said this was an age of progress, and they must progress with the rest of the world. He suggested whether an area could not be defined by the surveyor, and the Exeter Electric Light Company then be asked what they would light it for. An amendment that the matter be referred to the Lighting Committee was lost, and the motion was carried by 15 votes to 4.

Barnet.—The Barnet Local Board seem to be having the same trouble with gas as they complained of with the electric light—at any rate the demand for rebate on account of the lights going out are still brought up at the Board meetings. Barnet seems not only to want, like Goethe, "more light," but, like the South-Eastern Railway, "more regularity." It would be happy with either, and evidently will not be happy till it gets—at any rate the latter. Poor Barnet! what a long and weary struggle to obtain the light in its 70 odd burners, and all this continual fuss while many a private house has a large number of lamps; and the question of their electric lighting contract is still under arbitration.

Ulverston.—The lighting question at Ulverston is reaching an acute stage. There is no doubt, says Mr. Casson, that last winter they were near a gas famine. It is wished to put off the consideration of the extension of lighting power for a year, the chief reason for delay being

that one of the largest customers, the Lonsdale Iron Works, paying £240 a year, has now installed electric light. Electrical engineers can help the Ulverston Gas Committee in two ways—first, by taking off a few other big customers, such as the Paper Works; and secondly, possibly by the introduction of electric lighting into the town—though Mr. Tosh, chairman of the Gas Committee, thinks the cost of distribution would be too great at present.

Explosions.—In the discussion on Mr. A. L. Stevenson's paper on "The Present Condition of Transmission of Power," at the Society of Engineers, Mr. J. A. G. Ross said there was one danger from electricity often overlooked. When a fracture took place in a wire and moisture became condensed upon the broken part of the wire, the electrical current produced the electrolysis of the water—that is to say, the water became decomposed into its constituent parts of oxygen and hydrogen—and that in the exact proportions necessary to produce a most violent explosion, very much more violent than that produced by coal gas and oxygen. The process continuing, and a spark ultimately being produced, the electric wire thus becomes its own gas producer and its own exploder as well.

Presentation.—A ceremony of a very interesting character took place a few evenings ago at Cadiz, the occasion being the presentation to Mr. Charles Wilson, late superintendent of this station of the Spanish National Submarine Telegraph Company, Limited, of a handsome gold watch and chain, and to his wife of an exquisite gold bracelet. The watch bore the following inscription: "Presented to Mr. C. Wilson by the members of the Victoria Club and friends on his leaving Cadiz, March, 1892." The presentation was made at the clubroom before a large assembly of the English colony, and hearty good wishes were expressed for the future prosperity of Mr. Wilson in his new appointment as superintendent of the South American Cable Company's station at Pernambuco.

Turbine Regulator.— The *Revue Industrielle* for April 16 contains description and working drawings of a regulator of the Girard turbine for horizontal driving, direct coupled to a dynamo. The system is designed by MM. Gandillon et Vigreux. The efficiency of the turbine is given as 80 per cent., or even 82 per cent., with a minimum of 72 per cent. The regulator permits direct driving, and forms an economical installation. A plant has been recently installed for M. Theodor Haviland, at Montmény, Haute-Vienne. The turbine runs at 760 revolutions under a fall of about 55ft., and driving an Edison dynamo whose output can be varied from 42 to 55 amperes at 142 down to 110 volts. The lighting is so satisfactory that the Continental Edison Company are intending to adopt the system as a speciality for their installations.

Waterford.—The Waterford Lighting Committee have not yet presented their adverse report as expected. The borough surveyor, on the other hand, has drawn up a favourable report, showing that the town has saved £1,100 a year by the use of the electric light, while there are two miles more of streets lighted; the public lighting has been "steady and satisfactory." The present contract with Laing, Wharton, and Down expires in September. This was made without provisional order, but with full consent of the local authority. Wishing to put the matter right, they registered a Waterford Company, and notice of application was given. The Waterford Corporation applied for an order themselves, and, having obtained it, seem to desire to abandon it in favour of the gas interests. Such a policy, however, is not likely to find favour either with the inhabitants or the Board of Trade.

Free Trade in Telephones.—*Free Trade*, a journal which advocates its title as the solution of every social question, has a sweeping onslaught on the Government authorities with reference to the telephone question. "You say regulation of telephones is necessary because it involves public inconvenience or danger in overhead wires—so also are sausages full of danger," and the Government has as much right to step in and protect us against sausages, thinks this journal; but the "real truth" is "that Government want to preserve their message carrying intact because they want to open letters and read their contents." Touching Sir J. Fergusson's recent speech, however, is a word of wisdom. "There was a real danger," says the Postmaster-General, "of the telegraphs being injured by the telephones. What an unfortunate thing for Governments that people *will* progress! This shows the great evil of Government monopoly—that it stereotypes," and against this stereotyping action free-traders are urged to wage continual war.

A Synagogue Lighted by Electricity. — The Brighton Synagogue is the first synagogue in England to be lighted by the electric light. "Some of our readers," the *Jewish Chronicle* says, "can remember the time when gas superseded candles as the illuminant in certain synagogues. Now gas is being driven out in its turn, and the electric light is reigning in its stead. So conservative is the Jewish mind that the dethronement of candles was not acquiesced in without a murmur in every case. Gas was an innovation, and the 'auld lichts'—the men, not the illuminants—viewed its introduction into the synagogue with some misgiving. To this very day gas is refused admission into the Bevis Marks Synagogue, and the retention of candles made an article of faith. Even the quality of the candles is deemed a matter upon which to spend conservative energies. Some years ago our esteemed and vigilant correspondent, Mr. H. Guedalla, wrote to us stating that he had discovered a falling off in the quality of the candles burnt in the ancient synagogue, and entered his protest against the policy of which the deterioration was the outward and visible sign."

Toynbee Hall Science Conferences.—A lecture was delivered on Wednesday evening, April 13th, by Mr. Reginald J. Jones, M.I.E.E. and A.M.I.C.E., on "Electrical Installations," the subject being illustrated by lantern slides and very interesting experiments. The various methods of driving power were detailed. From actual practice, the average cost for five years of the gas used in a London house for driving a gas engine for an installation of 43 lamps, was shown to have been only £11. 12s. per annum. Storage of electricity was illustrated practically by E.P.S. cells lighting the lecture hall. Some positive plates were shown which had been in daily use for six years in a private installation, and the new form of Epstein cell was exhibited as promising to yield good results for electric traction and central station work. The steadiness of electric light as supplied from central stations was demonstrated by some remarkable E.M.F. curves taken in December last in foggy weather. The practical and theoretical conditions which govern the wiring of houses were fully illustrated and explained by slides, tables, experiments, and types of the most modern fittings.

Art Fittings.—The *St. James's Gazette* thus takes the warpath against inartistic fittings: "The opportunity which the introduction of electric light into our public buildings afforded to designers, for something of a higher standard than what has hitherto been produced for gas, has not at present been made much of. In churches, more especially, there was room for great improvement, for electric light fittings need be neither so cumbersome nor made of such

heavy-looking material as painted iron, seeing that gilt will not suffer at all through the action of the new illuminant. At the Kensington parish church there is at this moment a case in point. A huge chandelier has, tentatively we hope, been suspended in the centre of the nave—a position which we thought had been universally abandoned, as common sense shows that it must block the view of the east end and of both eastern and western windows. The chandelier in question is of the most primitive character, with absolutely nothing novel about it, and recalls, with its two hoops and pendant lights, the primitive machine upon which fairings were wont to be hung and swung at village wakes. In a parish teeming with artists, cannot a committee of taste be invoked? It is not so long ago that we had to call out against an unsightly new fresco, which, by the way, the new chandelier will certainly do something to hide."

Oldham.—A special meeting of the Oldham Town Council was held last week with reference to the establishment of a central electric station in the town. The Electric Lighting Committee asked the Council to confirm their recommendation, adopting Prof. Kennedy's scheme throughout. There would be some few details that would have to be arranged between the committee and Prof. Kennedy, but these details did not affect the scheme as a whole. Councillor Ingram read a detailed report on short-stroke direct-acting versus long-stroke belt-driving steam engines for electric light. The report stated: "At the request of Prof. Kennedy, our electrical engineer, the mayor, and myself, have been to London to see these direct-acting engines in actual operation. We visited three several electrical depôts, comprising some 5,000 h.p. to 6,000 h.p. At the oldest of these stations we spent some considerable time, under the most favourable circumstances, for they had one of their oldest engines all in pieces, to be thoroughly overhauled and repaired where necessary. We had, therefore, a very good opportunity of examining the construction and internal condition of all the working parts and wearing surfaces, etc. We saw the inside of the cylinders, the pistons, the valves, and steam passages, etc., and for an engine that had been working at this great velocity for over three years we were agreeably surprised; and yet, when the fewness of the parts, their light construction, and the excellent arrangements for internal and external lubrication are taken into account, the whole thing is explained and easily accounted for." The report concluded: "I have therefore come to the conclusion, notwithstanding my aversion to short strokes, that we may not only safely adopt these short-stroked single-acting engines which the committee recommend, but that they are decidedly the best adapted for this particular purpose." It was stated there was no street lighting in the scheme except one large lamp in the Market-place; this question would be considered subsequently. The recommendation was unanimously confirmed.

Engineering Exchange. — At the meeting of the Civil and Mechanical Engineers' Society, on the 13th inst., a paper was read by Mr. Reginald Bolton, vice-president, on the subject of the Engineering Exchange. The object of the paper was to demonstrate the close connection existing between the interests of Westminster engineers and the mercantile branch of the profession located in the City of London. Pointing out how disadvantageously situated Westminster engineers were in the disposal of their productions of ability and knowledge, by reason of locality and professional restitutions, the author went on to show how great is the need in commercial transactions of a more intimate connection of consultants with merchants. After some very instructive facts relative to the practices of agents abroad, and the difficulties of manufacturers who endeavour to do merchant work themselves, Mr. Bolton concluded with the hope that the considerations he had brought forward would impress on professional engineers the advantages of association with an institution formed for general convenience, and which was destined, with their co-operation, to become powerfully representative and worthy of that science of which the keynote is "progress," and of the age in which it has been inaugurated. A discussion followed, in which a number of members took part, when opinions expressed by the author were reinforced by facts related by several speakers, and some pertinent instances were given of the important purchases and sales conducted by civil and consulting engineers, and the establishment of the exchange was admitted to be of great value to them. The author, in replying, invited anyone interested to visit the temporary premises of the exchange in the exceedingly commodious and convenient clubrooms of the "Jerusalem, Limited, Billiter-street, E.C., and stated, as chairman of the Exchange Committee, that the opening would take place on May 2, previous to which circulars and application forms would be sent round the entire profession as far as possible. A hearty vote of thanks to the author closed an interesting evening's proceedings.

Sessach-Geltorkinden Electric Railway. — The following abstract from the *Electrotechnische Zeitschrift* is given in the *Journal* of the Institution of Electrical Engineers, describing the Sessach-Gelterkinden electric street railway. The line is 3½ kilometres long, with one intermediate station, and runs principally on the public streets. The sharpest gradient is about 1 in 70; the two sharpest curves are 60 metres, and one of these, being on a gradient of 1 in 85, is the part of the line which requires more power than any other. The power is obtained from a Jonval turbine, giving about 40 h.p. at 98 to 100 revolutions. The dynamo is a series machine, and runs at 600 revolutions, giving 700 volts and 50 amperes. The current is taken off by two pairs of copper gauze brushes, and it is found that there is much less injurious action on neighbouring telephone wires than when plate brushes are used. The load being very variable, and the cost of power negligible, the velocity of the dynamo is regulated by a brake. The dynamos are carefully protected from lightning, the guards consisting of carbon points set opposite to one another, and momentarily snatched apart by an electromagnet to break the arc when the machine current follows a discharge. The apparatus has so far always worked most satisfactorily. The current is taken by the cars by an overhead arm, from a hard-drawn copper rod ¼in. in diamer, which runs the whole length of the line, and is joined every 100 yards to a second insulated conductor carried on the same posts. Both conductors are on oil insulators. The rolling-stock consists of one locomotive, four passenger cars, and four goods waggons. The locomotive has two drum-armature four-pole 25-h.p. motors with radial carbon brushes, and will run in either direction. The axle of the driving wheels run loose through the base of the motor, and is connected to the spindle of the latter by gearing. The motor is kept approximately vertically over the axle by a strong spring, which, however, yields enough to prevent jars at starting. The lighting of the carriages is done by oil, as the E.M.F. is very variable.

Vibratory Currents.—Prof. Elihu Thomson contributes to the New York *Electrical Engineer* an account of some experiments he has recently made with currents of high potentials and frequencies. He has obtained sparks in air 31in. long, in apparently continuous streams of 250 a minute. In the first experiment Prof. Thomson describes an arrangement for giving an alternative path to the discharge, an incandescent lamp being placed in one of the

paths. The lamp is lighted with more or less brilliancy according to the turns, illustrating the presence of a neutral point. In his further experiments he employs 1,600ft. of wire to produce the sparks 31in. long in air at a calculated potential of 500,000 volts. A barrel of paraffin oil is used, and in this two coils on paper cylinders, that on which the secondary is wound being 3in. less in diameter than the other, and has an external diameter of 13in. It has two layers of silk, and on this 500 turns of No. 26 cotton-covered wire in one layer, with a silk thread between the coils. The primary consists of 15 turns of a conductor composed of five rather heavy wires laid alongside. A second apparatus in the shape of a trough has a primary of 10 turns and a secondary of 500 turns, with insulation of thick cotton wound on cardboard rolls covered with silk. The secondary terminals are taken up a glass vessel like two bottles together with their bottoms knocked out, fastened together and filled with oil, making a long narrow-necked outlet. With this apparatus excited from alternating-current mains, with a condenser (of six Leyden jars), and air gap with blast of air blowing across the gap, the sparks of 2ft. 7in. long can be obtained in air. These discharges pierce glass, and set heavy pine or oak boards on fire, scorch a line over a surface of wood, and soften glass passing over a sheet. A stick of wood is splintered and torn by the discharge, glass vessels are shattered, and inflammable matters set on fire. A beautiful effect is produced by the insertion of a sheet of stout glass, when the electrodes are separated about 24in. The use of fine wire coil to pass the discharge through reduces the periodicity, as also does the use of iron, and various notes may be thus obtained. The insulating power of oil is strikingly demonstrated. The perforation of 2in. of oil between rounded terminals of ½in. diameter would seem to demand a potential capable of causing a leap of 5ft. in air.

Electro-force Boots.—An old saying states "there is nothing like leather," but if there is nothing "like" it—as "Alice in Wonderland" says, of "eating hay for a cold"—there is some better, or, at least, Mr. Randall, who ought to know, is reputed to think so. Mr. Randall is the bootmaker the virtues of whose wares are advertised in various ways, but the latest dodge is the worst. Walking down the classic hill leading from St. Paul's to Fleet-street, we caught sight of the words, "Electro-force Boots—watch the effect on the magnet." Slowly revolving by clockwork were a pair of these special boots, whose gyrations caused erratic movements on two large magnets. This was all: and this exhibition was surrounded by a gaping crowd, looking at the "greatest invention of the age," as it was termed. The invention—save the mark!—is by Mr. H. G. Whiting, A.P.S., M.S.A., whatever this may be, and you are invited to step in, take a pamphlet, and buy boots—so much extra, of course (5s.), for being "electro-forced." The pamphlet starts off by stating that "electricity, magnetism, and odic force are the mighty forces of Nature now employed in so many ways for the benefit of mankind." Electricity, this pamphlet kindly tells us, is used in telephony, and even telegraphy; magnetism is hardly worth alluding to—but the boots, the boots, are the things to catch the—well, not conscience—but gullibility of the King—for we find "members of Royal Families" quoted as purchasers. And these boots are charged, we are told, with "odic-magnetism." "Odic force," says the pamphlet, "is continuous in its action and passes through any known substance, as demonstrated by its action on a balanced magnetic needle"! The odic force, it is stated, cures tender feet, cramp, chilblains, and even bronchitis. A purchaser must indeed be a tenderfoot to credit these statements. All this is the most utter nonsense, and however much Mr. Whiting, patentee and medical electrician, assures us in pamphlet that electro-force boots "soothe the nerves and renew brain power," Mr. Randall ought to know better than to countenance such measures for selling goods which sail perilously near false pretences. The magnet, which is concealed in the sole, affects the needle, and thence the eye and pocket of the purchaser, and that is all. "Odic-magnetism," or odic force, are unmeaning terms, and none of the statements have the least warrant of being based upon science, or upon anything more than a quack attempt to promise cures under guise of plausible names aided by most transparent tricks, and the whole thing is unworthy of the name of a respectable tradesman.

Coventry.—The Electric Light Committee presented to the Coventry Town Council the following report, received from the deputation which was appointed to visit the Electrical Exhibition at the Crystal Palace with the view of obtaining information as to the production and distribution of electric light: "The deputation, consisting of the Mayor, Councillors Webb Fowler, Goate, Starley, Thomas, and West, and the assistant town clerk, visited the Exhibition on Friday, the 11th inst., and spent about eight hours there. The principal stands visited were those of the Brush Company, Crompton and Co., the Electric Construction Corporation, Laing, Wharton, and Down, and Siemens Bros., at all of which every courtesy was shown, and information readily given. The principal question to which the deputation directed their enquiries was that of the system of distribution to be adopted. Upon this the information gained has led them to the conclusion that of the two systems in use, high and low tension, the former appears to be more economical and better suited to the circumstances of Coventry. Its leading advantages are (1) a great saving in the first cost on account of the smaller mains required, and (2) the fact that the current can be conveyed for a distance which is practically unlimited, whereas a low-tension current cannot be used more than 800 yards from the generating station. It would thus be possible, were the high-tension system adopted, to place the generating system in any part of the city or suburbs, and, should a refuse destructor be erected, to place the two side by side, and to use the heat from the destructor as part of that required in the boiler of the generating machinery. But apart altogether from the last consideration, the deputation are of the opinion that the greater area over which the current from one central station can be used on the high-tension system would be a distinct advantage in Coventry, where consumers are likely to be scattered over the whole city. The deputation also enquired into the different systems of laying mains and the various kinds of engines used in generating stations, but on these questions they are not prepared to express an opinion except that further information should be obtained. In consequence of the visit of the deputation an eminent firm of electrical engineers has offered to submit, free of cost, a scheme and estimate for the establishment of a central electric light station at Coventry. The deputation beg to recommend that this offer be accepted, and that any similar offers from firms of like standing should also be accepted." The Mayor, in moving the report, said the committee differed from Mr. Bromley Holmes in some particulars, but thought, when he knew the requirements of the city, he would meet them half-way. Alderman Marriott thought the report satisfactory, and hoped the committee would avail themselves of all time allowable before submitting any particular scheme. The report was unanimously adopted.

THE CRYSTAL PALACE EXHIBITION.

In the Machinery Hall there is an exhibit which cannot fail to greatly interest a very wide circle of visitors, that of **Messrs. Lloyd and Lloyd,** who show an enormous variety of tubes electrically welded by the improved Benardos process. Steam-pipes and hydraulic-pipes of all shapes and sizes are exhibited: small pipes jointed together at curves and angles, large pipes jointed with smaller pipes; cisterns, tubes, retorts, bends, curves, and loops of all kinds—all neatly and firmly welded with exceedingly workmanlike joints.

Messrs. Lloyd and Lloyd were the pioneers in the manufacture of gas-welded wrought-iron and steel tubes of large diameter. At their works the first plant for this purpose was put down and all preliminary experiments made. After years of costly experimenting, they succeeded in its application, and became the first manufacturers of large gas-welded tubes, and the process was adopted by large manufacturers like Mr. Samson Fox and Messrs. John Brown for making corrugated tubes. The gas welding was, however, found too costly and difficult of application, and attention was turned to electricity as a more reliable and convenient means of heating. The results of the employment of the Benardos arc-welding process, as improved by them in practice at their Coombs Wood works, are seen in the striking exhibit at the Palace.

The process of welding is simple. An ordinary low-tension continuous-current dynamo is used, connected to a large battery of accumulators. When the welding circuit is closed, the current from both dynamo and battery flows through a large regulating resistance. By this arrangement a very large current can be obtained, and the load factor of the engine is high. In parallel with the main circuit, as many welders as desired are connected, every welder being able to vary his current. One terminal of the circuit is connected by means of a flexible cable to a large carbon held in an insulated holder, which is used by the workman as a tool. The other terminal is either connected to the table on which the work is placed, or to the work itself. An arc is thus sprung on touching between the metal and the carbon, the strength of which can be regulated both by switches and by moving it by hand. It is found advisable to work with as long an arc as possible, as the heating effect is then more regular. It is possible to obtain an arc 6in. long having a sectional area of arc of about two square inches. When iron or steel is being welded, it is usual to make the carbon the negative pole, and the iron or steel the positive pole; but for other metals, especially for lead welding, the poles are sometimes reversed. The accumulators used are of the Planté type, manufactured under the Benardos patents by Messrs. Lloyd and Lloyd themselves. They are designed so that they may be discharged at a rate which would be ruinous to a pasted plate.

In working, the eyes of the workmen are covered with protectors of coloured glass, as if the eyes are exposed even momentarily to the full glare of the arc a disagreeable and possibly injurious effect is produced. In welding tubes the parts are cut out to shape by the arc itself, brought to a welding heat and placed together. One of the principal improvements introduced by Lloyd and Lloyd consists in a mechanical arrangement for distributing the heat of the arc, which is made to gyrate or vibrate at considerable speed, and travel backwards and forwards, so distributing the heat over a given surface. In conjunction with this arrangement a power hammer driven by an electric motor is under the control of the workman, and can be instantaneously brought into operation when the metal is sufficiently heated. Rapid working is found necessary to ensure success. The men, even ordinary workman, are found to manipulate it easily, and no workman has suffered in health or eyesight. The practicality of the process has now received full demonstration after two years' constant use, and the large number of purposes for which it is applied are *witness of its success.* In large pipes over 6in. diameter it is peculiarly advantageous, as pipes of these sizes could hardly be welded at all. Now large fittings can be made from thin steel, and such fittings, 12in. diameter and only $\frac{5}{16}$in. thick, have been produced and tested to 800lb. per square inch. For hydraulic work the electrically-welded tubes have shown themselves a great success. The diameter of these tubes usually does not exceed 2in., but they are always tested up to pressures of from 1,000lb. to 3,000lb. per square inch. All kinds of curved combinations are found possible, and the weld successfully resists torsional as well as bursting strains. Iron barrels is another branch where electric welding is used. They are largely made for Russia for the conveyance of petroleum. A factory has been started in Germany devoted to their manufacture.

Repairing steel castings is another branch of metal work in which the process has shown itself a great success. Messrs. John Spencer and Sons, Limited, have an installation at their works, and when a casting shows signs of unsoundness it is taken to the welding shop, the defective part is removed and the hollow place is filled in by fusing small pieces of special steel into it. The economic results in this department are of extreme importance. A still further application of the electric arc is for cutting and boring the metal itself. Where large plates, girders, or masses of iron or steel have to be cut out to special form, or to template, the arc shows itself a tractable tool. With it as much work can be done in an hour by burning or fusing away the metal as in ten with a cold sett, and the welder can be carried to the work instead of shifting the heavy metal. Both in this country and in Russia the process has been largely used for the repair of engineering work of various descriptions: Facing points, where worn, when repaired, are found to last longer than new ones; engine frames; locomotive wheels, some with as many as 15 cracks in the spokes and felloes; engine valves mended with phosphor bronze; valve frames, where worn by friction; cross heads, axle necks, links—in fact, all parts of the engine to which it is possible to apply the arc. At Coombs Wood large wrought-iron pump rods and large forgings have been mended. As showing the wide range of possible applications to repairing, the following may be mentioned: Long steel rolls, broken through the necks, afterwards carrying weights of four tons; a patch put on the boiler of a steam crane, in constant work since for several months; a hot-water boiler for a low-pressure heating system; a leaking silver cream-jug; and a gold sleeve-link.

The process has been found useful in lead welding, and for this purpose a small carbon and 10 amperes are sufficient. The work is done with ease and rapidity, the heat being produced exactly where required. It is interesting, further, to notice that different metals can be welded together when required. The two surfaces are brought to a white heat, and rapidly brought together and pressed or hammered, if necessary. A specimen is shown at the Exhibition of a steel plate plated with copper welded together in this manner, and other metals can be treated in the same way. The exhibit at the Palace is quite sufficient to indicate the extreme and growing importance of the arc process of electric welding, and Messrs. Lloyd and Lloyd are to be congratulated on the enterprise and energy with which they have taken up the process.

While writing of tubes, we must mention the exhibit of **Mr. John Spencer,** of the Globe Tube Works, Wednesbury and London, which every visitor interested in mechanical or electrical matters has probably noticed opposite Messrs. Crompton's crane. Tubes now bear a very large proportion in the various extraneous supplies required in electric lighting, both for steam-pipes, electric conduits, and also for electric lighting and telegraph poles. The Spencer tube exhibit sets forth the various uses of tubes in great variety: tubes for water, for steam, for under and over ground use, for oil insulation, tubes enamelled inside for steam or wires, besides a large assortment of bends, curves, tees, sockets, and elbows, in as interesting form as these somewhat prosaic articles allow. An exhibit which, however, appeals more directly to electrical engineers, is a very simple arrangement of small tubes in tripod fashion, with struts and binders at intervals, forming a simple,

light, cheap, and easily-raised standard or post for electric lamps in streets and workyards and other similar use.

On the stand of **The General Electric Company** is exhibited the Aron meter, now well known all over England. The question is forced on the minds of everyone having to do with central station work as to which meter before the public is the best. The following considerations in favour of the Aron meter may not be out of place at the present moment. Leaving on one side the alternate-current meters, direct-current meters divide themselves into the following categories: (1) Chemical meters, of which Edison's is the best-known example; (2) magnetic field meters, of which the Aron is the type; (3) motor meters, such as the Hookham meter, Elihu Thomson's, and Teague's; (4) rotating mercury meters, as Ferranti's; and (5) semi-integrating meters, as Frager's, Richard Fréres', and, it is rumoured, Sir W. Thomson's latest. All these, except the last, are in the market, but it is pretty certain none can show what the Aron meter

The Aron Electric Meter.

has done—a sale of over 4,000 in England alone, and a total of 12,000 in actual use. The disadvantage of the chemical meters are difficulty of reading, expenditure of power, stoppage from freezing, and greater want of accuracy, besides absence of direct reading. The motor meters act splendidly in the laboratory or test-room, where all connections can be looked to, and all bearings are fresh, but in practice they hardly ever work so well. Further, their errors are all for the consumer and against the company—they are the philanthropic meters. They can never go too fast, but they certainly can go slow, or even stop. Then there is usually no great range—say, 1 to 30. But a meter should register 1 to 100, or even 1 to 500. In the rotating mercury the whole registering gear has to be driven by the current, and the slightest dust or friction is against the company's account. In the integrating meters, though in a less degree, there is still the question of connections and bearings. In the Aron meter there is one principle which ensures absolute correctness on constant work to within ½ per cent. or less, without liability to get out of order—the influence of a solenoid on a swinging magnet retarding a clock pendulum, or if preferred, the influence of solenoid on solenoid. The Aron meters are in use constantly at Westminster, Kensington, Knightsbridge, St. James's, St. Pancras, Chelsea, Metropolitan (Whitehall), Electricity Supply (Gatti's), Brighton, Bradford, Preston, Glasgow, Newcastle, Sheffield, Southampton, Northampton, and other central stations, in many instances for several years—a great proof of their satisfactory character.

No attempt has been made at the Palace to produce similar effects to the magnificent fountain effects obtained at several exhibitions at South Kensington, though if the weather was warmer grand displays might be made in the grounds of the Palace and with the numerous fountains therein. As aiding the spectacular effect in the Palace, the fountain in the Central Transept has its use. It has been prettily decorated by **Messrs. Laing, Wharton, and Down.** The effects are obtained by means of incandescent lamps and coloured covers or transparencies, principally, if not wholly, shells. Scattered about on the inside walls of the pit are about 100 8-c.p. lamps, divided into four circuits. Besides these there are four 100-c.p. glows, placed equidistant round the pit. About half-way down these are coloured red. At another four points at the same depth there are four more 100-c.p. coloured yellow, similarly four coloured green, whilst at the bottom and lying under the falling water is a 500-c.p. Sunbeam. There are thus four switches for the four circuits of shells—three switches for red, yellow, and green lamps, and one switch for the 500-c.p. Sunbeam lamp. An attendant in charge of the switches plays variations. Thus the four circuits of shells are usually put on or switched off together; then the four yellow are switched on, or the four red or the four green, while the 500-c.p. is put on with any of the coloured lamps—yellow, red, or green. The switchboard is placed in front of the fountain on a table. Illuminated signs are placed in the fountain at the bottom, one on each side, and larger signs are placed at the top of the fountain pit on the Palace floor. These can be changed in colour, one switch making them red, another yellow. The lights are run from a combined Robey engine and L.W.D. "Special" dynamo. The engine is a compound vertical, having a speed of 350 revolutions, with the dynamo on the engine bed-plate, and coupled direct. The engine and dynamo will work 400 16-c.p. glows at a pressure of 100 volts. The fountain lights are run from 5 p.m. until 9 p.m. every night, the illuminated signs being left alight until 10 p.m.

THE WESTERN ELECTRIC (BELL TELEPHONE) FACTORY.

The telephone is not an indigenous plant in this country, and it is elsewhere we must look for the secrets of its development and the processes of its manufacture. The most important of the telephone factories of the Old World is to be found at Antwerp, though in the future we may, as we have done so often in the past, find an extension of operations in Great Britain. It is said that Englishmen, far from being eager to embark in new ventures of manufacture, are quite willing to let other people prove the merits of the apparatus and then come in with money and organising ability to compete in the manufacture. As regards telephonic apparatus manufacture, it will take us all our time to improve upon the organisation at Antwerp. For some time past rumours as to its excellence have reached us, and when a favourable opportunity offered for visiting the factory we were glad to take advantage of it. The Great Eastern Railway Company studies carefully the requirements of its continental traffic, and if a special train service, in connection with an admirable fleet of large, speedy well-equipped vessels, lighted throughout by electricity, is any advantage, this company should easily claim first place in such traffic. Its boats, both to Rotterdam and to Antwerp, are exceedingly comfortable, and the officers pay the greatest attention to the comfort of the passengers. The journey from London to Antwerp takes from 12 to 14 hours, according to the state of the tides. Thus, leaving London at eight o'clock at night we reach Parkeston Quay just before 10, and the boat is fairly on its journey at 10. Those to whom a short voyage possesses no terrors obtain a good night's rest in their berths. Flushing is reached about five o'clock in the morning, a new pilot taken aboard, who takes charge

up the Scheldt. Long before Antwerp is reached the historic tower of its cathedral is seen, and a good view of the town is obtained as the vessel glides along the river, right to the further end of the town. A train is in waiting to take the travellers further onward towards their respective destinations, but our objective is the Rue Boudewyns, where stands the factory of the Bell Telephone Manufacturing Company, better known here as the Western Electric Company. A call at the hotel—a telephonic signal—and over the Antwerp line we recognise the voice of Mr. Kingsbury, who for the time has forsaken 79, Coleman-street for the shade of the factory. The day and the time prove convenient, and very soon we reach the factory gates. Before referring to the organisation of the factory, it may be convenient to consider briefly the requirements of telephony. As has been said above, the telephone is an exotic. It was reared in America, and, unlike most pieces of apparatus, the receiving instrument of Bell sprung forth almost as perfect from the inventor's hands as it is to-day. The transmitter needed a Hughes to show what a world of utility lay in loose carbon contacts. Then came the application to mercantile and business requirements, till to-day there is hardly a city of any size but has larger or smaller telephone exchanges. The success of any exchange depends upon several factors. The instruments in the hands of the subscribers must be good, the connecting wires should be arranged to give rise to no induction troubles, and the exchange should connect subscribers with certainty and celerity. Then, again, telephone manufacturers have to provide for various wants, those, for example, belonging to public exchanges and those for single users or domestic and factory requirements. It is not difficult perhaps to provide an excellent piece of apparatus for private use. The connections here are either permanent or the changes few in number. Just consider for a moment the requirements of the simplest system of one speaker and one listener. There are, and must be, broadly speaking, four parts to the apparatus: (1) the transmitter, in which the sound-waves are taken up at the speaker's end, modifying the electrical conditions in the circuit, and being reproduced in a more or less intense form at the listener's end; (2) the receiver, by means of which the sound-waves are reproduced; (3) the electrical connections of the circuit; and (4) some means by which the would-be speaker can call the attention of the desired listener. Taking these parts in the reverse order, the ordinary means of attracting attention is by the aid of an electric bell. This supplementary part of the apparatus—that is, supplementary, so far as the talking is concerned—has to be added to the apparatus so as not to diminish its efficiency, nor to demand extra wires—in other words, the arrangement must be such that the telephone line wire is also the signalling wire. The actual conducting wires are usually of copper, bronze, or iron, with earth returns, and call for no special remark here. The Bell Telephone Company, or, as it is better known to our readers, the Western Electric Company, has devoted a great amount of skill and talent to the perfection of a magnetic signalling apparatus wherewith to get rid of the troubles which arise by the use of batteries. This magnetic apparatus is greatly appreciated, and has been adopted by almost everyone. It consists of an armature rotating between permanent magnets; in fact, its construction is so well known that description is unnecessary, and especially so when we are dealing, or intending to deal, with factory organisation rather than apparatus constructed, although, like the preacher, we may be long in getting to our text. We are endeavouring, however, to indicate that the manufacture of telephonic apparatus on a large scale calls for business and organising powers of a high quality. Resuming, then, the reference to the parts of apparatus, the signalling accessory is the best and most ingenious known, and the transmitter and receiver are about as perfect as can be made. The greatest ingenuity, however, is found displayed in the switchboards which are necessary for exchange work. How complicated, or how simply complicated these become, is of the utmost importance. The fewer the operations the less probable is trouble from subscribers because of mistakes. For years past the Western Electric Company has continually employed the services of experts to investigate the working, to perfect the apparatus, and to enable the company to produce the best possible mechanism for the purpose to be achieved. Consider one speaker and two possible listeners. There must be an arrangement by means of which one possible listener is cut out of circuit. Have two possible speakers with two possible listeners—say, S_1 S_2 are the speakers, and L_1 L_2 the listeners—the apparatus must allow the following combinations: S_1 with L_1, S_1 with L_2, S_2 with L_1, and S_2 with L_2; while if the listeners are to become speakers the combinations provided must be S_1 S_2, S_1 L_1, S_1 L_2, S_2 L_1, S_2 L_2, and L_1 L_2. Further, suppose the number of subscribers to be, not four, but four thousand or forty thousand, then the problem becomes to find the simplest connections and apparatus which allows any one of these subscribers to be put into communication with any other subscriber, without the possibility of conversation being overheard or interrupted. A study of the Western Electric exhibit at the Crystal Palace Exhibition will show the admirable way in which their portion of the business is done. It will be found that, not only the switchboards, but all parts of telephonic apparatus consist of a large number of small parts, and it becomes necessary in the manufacture to organise a factory—that is, if the apparatus is to be produced at a reasonable price—so that these various parts may be produced at the cheapest rate in large quantities exactly to pattern. The factory in the Rue Boudewyns has been erected and equipped with the one object to produce the best work at the lowest cost. The whole equipment has been under the direct supervision of Mr. De Warr, who laboured under the difficulty of not understanding one word of Flemish when he arrived in Antwerp, but who has nevertheless surmounted all difficulties, and at the present time has the control of over 600 workpeople, to most of whom Flemish is the mother tongue. A large proportion of the workpeople are girls, who are found to be on the whole more trustworthy than men. Quite a number of the machines are tended by girls, who become exceedingly dexterous in their work. One peculiarity an Englishman notices in the factory is that the machinery is wholly American, from the 160-h.p. engine downwards. There is, we think, but one exception, if the emery wheels are excluded. This peculiarity, however, ought not to be unlooked for. The Americans seem to have altogether outstripped us in the race for providing machinery for small delicate productions—as witness the machinery for constructing the various parts of watches. It would perhaps be interesting to describe quite a number of the machines used, but it would hardly be fair to those who have with immense pains and skill developed the work. Suffice it then to say that from first to last almost every operation is carried out by machinery—and by machinery of such a character that the attendant can hardly make a mistake. Take the boring of holes: the piece is rigidly fixed, and if the attendant wished, he or she could hardly get the holes of the wrong size or in the wrong place. Again, in the making of certain screws, the girl attendant just puts in the raw material as quickly as she can and the complete screw falls into a tray. It is almost incredible to find that a girl is thus enabled to produce several thousand screws per hour, all so exactly similar that the stock-room attendant merely shovels these screws into scales, counting them like bank cashiers do sovereigns—by weighing. At another point we notice slabs of brass being run through a machine, portions of the requisite size being punched out and shaped, and passed on to girls who soon fashion the rough material into the finished wheel. Thus, we may take it, a good deal of the raw material comes in at one end of the room and passes out into the storeroom in the finished state at the other. Some parts have, however, to be polished, some to be electroplated. These are taken to special departments, and gradually, in the finished state, find their way to the stores. There are also polishing-rooms for woodwork, testing-rooms for all electrical parts, and finally the fitting-rooms, where the parts are put together. The beauty of make and finish is better understood by a visit to a fitting-room than to any other part of the factory. The less the manual labour actually employed in the fitting-room the more nearly is the perfection of the

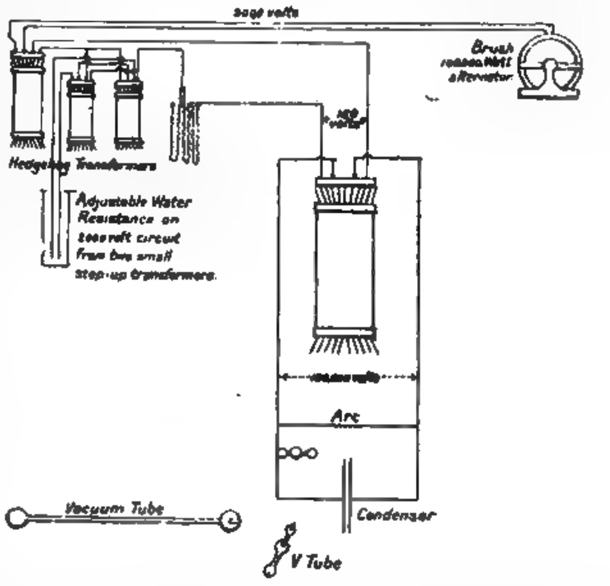
manufacture of parts obtained. The output at Antwerp, exclusive of the switchboard department, is from 160 to 170 of the ordinary telephone sets, and about 80 of the watch telephone sets per day. Special attention has also been given to a domestic set of apparatus, for which there seems to be indications of very large demands in the near future. We have said sufficient to indicate the important position of the Antwerp factory. It is but natural that Mr. Kingsbury, who has so long and so ably represented the company in England, and Mr. De Warr, under whose supervision these excellent results are obtained, should be proud of the industry which has grown up under their fostering care.

MESSRS. SWINBURNE'S HIGH-TENSION EXPERIMENTS.

There is an extraordinary fascination in watching man's supremacy slowly increase over the giant forces of Nature. Steam is now no longer feared even at pressures which would have made Watt himself, the great steam-tamer, pale with misgiving. Timorous persons will now trust themselves with calm confidence to the risk of trains speeding at 50 or 60 miles an hour, when once the idea of 15 or 20 brought the heart in the mouth, and we now must turn to the dreams of inventors—the electric train built for a speed of 400 miles an hour, or the ideal flying machine itself—if we wish to bring to the minds of to-day the breathlessness of early times. Something of this kind of thought must have passed through the minds of the representative assembly of electrical engineers who were drawn together on Wednesday last week, to the dim-lighted recesses of the Prince's Room at the Crystal Palace, in response to Messrs. Swinburne and Co.'s invitation, to witness the performance of their 130,000-volt transformer. It is not so very many years ago that the same feeling of daring was called up by Mr. Ferranti with his jump from 100 volts—then the ordinary pressure—to 2,500 volts at one bound. His later leap, from 2,500 up to 10,000, caused the same feeling of wonder, and perchance of overwhelming danger, forebodings now subsiding in the levelling power of custom. Then came Messrs. Siemens's Frankfort experiments with 25,000 volts, and later their beautiful demonstrations now to be seen in the Pompeian Court at the Crystal Palace, where 500 lamps are run in series, and the lightning-like discharge over glass demonstrates the powers of the enormous potential of 50,000 volts. Mr. Tesla in his classical lecture (which we are glad to be able to begin in revised form this week) spoke of, and doubtless obtained, pressures rising to some hundreds of thousands, even millions, of volts, which, curiously enough, by multiplying up the frequencies of alternation became practically harmless, approaching in its effects the discharges of an induction machine. The enormous voltages then spoken of have inspired still higher flights in pure alternate-current transformation, and in the 130,000 volts produced by Messrs. Swinburne we have the highest point yet reached in actual current from the secondary of a transformer on this side the Atlantic. We have to add these last words, for at the very time Messrs. Swinburne's invitation reached our hands there also reached us the account, which we give in abstract this week, of still higher flights in electrical potential from the laboratory of Prof. Elihu Thomson, who, with small coils in a barrel of paraffin, produced pressures reaching, he states, half a million volts, giving sparks nearly 3ft. long in air.

What the outcome of all this forcing up of enormous potentials will ultimately lead to no one can yet pretend to say, but that an extreme usefulness in the long-distance transmission of power from natural resources may eventually be looked for in this direction, most electrical engineers seem inclined to agree. A telling example of the possibilities in this direction has been mentioned by Mr. Swinburne, who stated that with the current from his latest transformer 50 h.p. might, were the wire laid, be transmitted along a strand of wire no thicker than a hair from Niagara to London itself, with a loss of only 2 h.p. on the route, or 4 per cent. Prof. Elihu Thomson is credited with practical views upon the utilisation of these great pressures, and in the field for experiment on a grand scale soon to be opened at the Chicago Exhibition we may perhaps see these veritable lightnings harnessed and set to work lighting cities, driving factories, and performing all the arduous mechanical work of mankind.

In spite of the knowledge of the fact that the fear of a thousand volts, or even of ten thousand volts, had been long almost forgotten, and that a hundred thousand or so should also be tameable by man's wits, it was, no doubt, with something of awe that the visitors saw Mr. Bourne and Mr. Swinburne, as lecturers, in evening dress, surrounded with a bewildering array of wires, transformers, and apparatus through which passed current at 130,000 volts, and it could easily be understood that the demonstrator in his experiments preferred to watch the switch rather than to lose his control of the force in watching the effect of the currents he was manipulating. Mr. Swinburne in a few words explained the arrangement adopted, a diagram of which, by his kindness, we are able to give herewith.



The current was obtained from the large 100,000-watt Brush Company's Mordey alternator in the Machinery Hall of the Palace Exhibition. This current was led in at the pressure of 2,000 volts, and first reduced by a step-down "Hedgehog" transformer to 150 volts. This was to allow the manipulation of the switches to be perfectly safe. The current was transformed up once more and passed into the primary of the 130,000-volt "Hedgehog," which was contained in a tall earthenware drain pipe, standing 5ft. or 6ft. high, filled in with oil insulation. The exciting current was passed in series through a water resistance in a similar drain-pipe tank, having a metal plate at the bottom, and a conducting float which could be raised or lowered in a simple manner by a crank handle. The high-tension transformer, it was explained, was to all intents and purposes an ordinary "Hedgehog," with paper insulation, thoroughly baked and then exhausted and filled in with hot oil: to prevent difficulty with sparking the terminals are taken out, one at the upper and the other at the lower end of the tank, in the method first suggested by Gramme for high-tension induction coils. There would be no difficulty, it was stated, in producing 150,000 or 160,000 volts from this transformer.

The first experiments showed the lighting of vacuum tubes by induction, a reproduction of the Tesla experiments. The high-tension current was led to a primitive condenser, made up of a few sheets of tinfoil separated from each other by a heap of brown paper. A break was made in the circuit, where an arc could pass, and this arc was arranged so that it could be blown out by means of a foot blower, as in Tesla's experiments, to obtain a surging vibratory current, but the break in Swinburne's experiments was made on the high-tension current, and not, as arranged by Tesla, in the low-tension circuit. Vacuum tubes were brilliantly lighted when placed near the wires, or anywhere in the electrostatic field.

The next experiment showed that slate, usually considered a good insulator at these pressures, became a good conductor. Mr. Bourne fitted a pair of ordinary slate pencils as the arc carbons, and a long buzzing arc was immediately struck from these slate pencils. They, however, soon grew hot by the added resistance. Experiments were then shown of the striking distance of this high potential. Two ordinary ladies' bonnet-pins were taken and arranged some inches apart: the arc struck easily across 5·2in., and could be obtained, it was stated, across 8½in. An experiment was also shown to demonstrate the fact that the arc will not strike with anything like the same ease between polished brass balls, as only between 2in. or so would it strike; and a peculiar fact was pointed out that the arc between polished balls left no perceptible trace on the metal.

A further demonstration of the conducting power of slate at these high pressures was shown by the use of an ordinary roofing slate, to and from which the high-tension spark easily passed. A striking experiment, in which Mr. Musgrave Heaphy evidently took special interest, was the passing of the current through a piece of wood. Little bright stars appeared amongst the cracks in the wood, and after a minute or two the whole length burst into violent flame.

The next experiment was an important one, to demonstrate Mr. Swinburne's contention that oil insulation, contrary to the statements of David Brooks, Mr. Tesla, and Prof. Hughes, is not self healing after the passage of a spark; at any rate when there is any power behind it, and actual current can flow. The two terminals were inserted in a vessel of rosin oil, and brought to within ⅜in. or ¼in. of each other. A spark passed and the oil burst into a violent, spluttering flame, which continued while the current remained on—as Mr. Swinburne remarked, a transformer with a flame in it such as that could hardly be said to be self-healing. A curious effect was next pointed out by Mr. Bourne, in a cuplike cavity caused on the surface of oil, over which one of the terminals was placed at a distance too great for actual discharge: this effect was attributed to the bombardment of the charged particles of air.

The discharge of the high-pressure current over the surface of a glass plate—termed by the experimenters the "electric octopus," from its winding arms of flame—was shown, and vividly impressed spectators with the almost uncontrollable power of the full pressure from the transformer. The glass plate was pierced and smashed by the force of the discharge. A last and most striking experiment was the direct discharge of the full pressure through a vacuum tube several feet long, furnished with electrodes which were connected to the two high-pressure terminals. A most brilliant glow suffused the whole tube, lighting up the entire room, and giving sufficient light, as we tested, to enable small print to be easily legible 10ft. or 12ft. away. The whole set of experiments were intensely interesting, and Messrs. Swinburne are to be congratulated on their production of satisfactory apparatus capable of standing such pressures.

Amongst those who witnessed the experiments were: Prof. W. E. Ayrton, Mr. T. H. Blakesley, Sir Frederick Bramwell, Prof. Viriamu Jones, Mr. Musgrave Heaphy, Dr. A. Muirhead, Prof. Robinson, Captain Henshaw Russell, Mr. J. W. Swan, M.A., Mr. Desmond FitzGerald, Mr. Wimhurst, and others.

AN INTRODUCTION TO QUALITATIVE CHEMICAL ANALYSIS.

BY BARKER NORTH, ASSOC.R.C.SC. (LOND.),

Joint Author of "Introductory Lessons" and "Hand-book of Quantitative Analysis."

(Concluded from page 354.)

PREPARATION OF REAGENTS.

It may often happen that the student cannot procure some of his reagents, so that it will be necessary for him to prepare them, and in any case, whether he buys them already prepared or makes them himself, he will find it a great advantage to acquire the manipulation and to have a knowledge of the making and purifying of reagents. In most cases the commercial salts will be quite pure enough for ordinary qualitative analysis, but it will occasionally be necessary to purify them by recrystallisation before they can be used with safety.

Crystallisation.—With few exceptions, when water is heated, it is capable of dissolving a greater weight of a soluble substance than when cold, and, therefore, if we make a saturated solution of any substance at the boiling point, on allowing the liquid to cool, the water will no longer be able to hold the whole of it in solution, but some will be precipitated as a solid. If the liquor cools slowly well defined crystals of the substance will be formed, hence the term crystallisation.

Recrystallisation of Copper Sulphate.

Experiment 31.—Dissolve about ½lb. of commercial cupric sulphate in hot water in a porcelain evaporating-basin, and boil the liquid till it is saturated at the boiling point—that is, till it shows signs of crystallisation while still hot. Cover up the basin and allow it to stand for several hours till quite cool, when it will be noticed that the bottom of the basin is covered with fine, large, blue prisms. Drain off the mother-liquor and treat the latter as before, by evaporating down till it is saturated and then allow it to crystallise overnight. The crystals thus obtained should be recrystallised two or three times in the same way in order to completely separate it from the iron which is generally present as an impurity. When the crystals are obtained pure, they may be washed with a little water and dried well with blotting-paper.

Other salts may also be purified in the same way.

Preparation of Copper Sulphate from Copper, etc.

Experiment 32.—In some cases it may happen that the student may not be able to obtain the different salts—such as copper sulphate and nitrate, zinc chloride and sulphate—and these may then be obtained from the different metals by dissolving in the acid corresponding to the salt required, afterwards crystallising out from the filtered liquor in the manner above explained.

Cover about 50 grains of metallic copper in a flask with strong sulphuric acid and warm till all action ceases, taking care, however, to have the copper in excess. Filter and crystallise out the copper sulphate in the usual manner.

Preparation of Platinic Chloride from Scrap Platinum.

Experiment 33.—Waste pieces of platinum wire or foil which are no longer of use in testing should be preserved, and, when a sufficient quantity has been obtained, made into platinic chloride. In order to accomplish this the metal is dissolved in aqua regia, which consists of one part of strong nitric acid mixed with three parts of strong hydrochloric acid, and the liquor evaporated down to get rid of the excess of acids. Dilute with water and add a solution of ammonium chloride to precipitate the platinic chloride as the double salt $PtCl_4,2AmCl$. This is filtered off, on a Swedish filter-paper if one can be procured, and afterwards washed well with alcohol and dried. The precipitate is now transferred to a porcelain crucible, and if Swedish paper has been used it may be burnt and the ash added to the precipitate, the whole being then ignited gradually to bright redness for several minutes with the foot blow-pipe. By this means nothing will remain, if the experiment has been carefully conducted, but pure spongy platinum, which may be again dissolved in aqua regia and evaporated down to dryness several times with hydrochloric acid, so as to get rid of the excess of nitric.

The pure salt is dissolved in 10 parts of water, and the solution will then be ready for use.

Preparation of Silver Nitrate from Metallic Silver.

Experiment 34.—Silver nitrate may conveniently be prepared from a silver coin, such as a sixpence, by dissolving in warm nitric acid in a small flask. When the metal has quite disappeared add dilute hydrochloric acid till all the silver is precipitated, and filter off the chloride of silver on a large paper, afterwards washing the precipitate well to get rid of the unprecipitated copper.

The silver may then be recovered by either of the two following ways :

1. By fusing the pure chloride of silver on charcoal with fusion mixture in the ordinary way, and afterwards dissolving the bead of silver, which has been previously cleaned with hydrochloric acid and water, in nitric acid. The solution is evaporated to dryness, the residue gently fused, and then dissolved in 20 parts of water, filtering if necessary.

2. By bringing the washed chloride of silver prepared as above in contact with clean strips of zinc and dilute sulphuric acid in a porcelain basin, the precipitate may be reduced to the metallic state, the chlorine being taken away by the zinc. The silver thus formed is collected on a filter-paper, washed with dilute sulphuric acid and water, and finally dissolved in dilute nitric acid, from which solution the pure silver nitrate may be obtained by evaporating to dryness and gently fusing as before.

Preparation of Other Reagents.

With the manipulation thus acquired, and the knowledge of theoretical chemistry already possessed by the student, he will now be able to prepare any other reagent which may be needed.

HOW TO MAKE A SULPHURETTED-HYDROGEN APPARATUS.

As a large quantity of this gas will be required for analysis, and in many cases only a small quantity at a time, the student will do well to provide himself with an apparatus such as is shown in Fig. 16, by which means he will

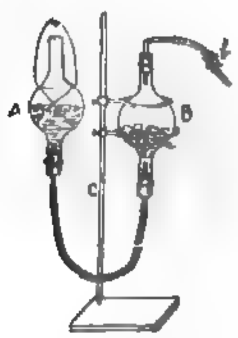


FIG. 16.

be able to generate a stream of sulphuretted hydrogen at any time and stop the same when necessary. If a small quantity of sulphuretted hydrogen only is needed, the apparatus figured in Fig. 8 may be employed, but for all practical purposes one of the two following arrangements is the best.

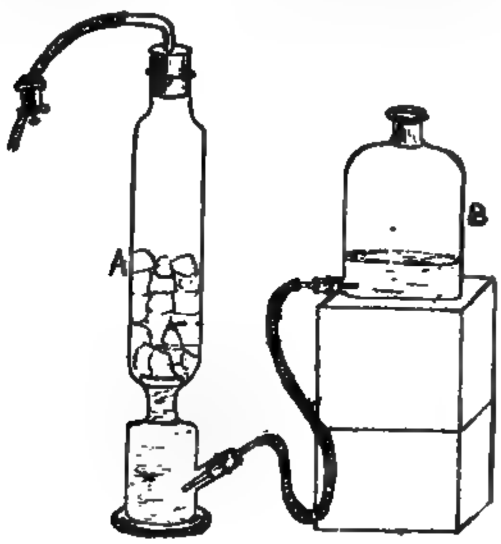


FIG. 17.

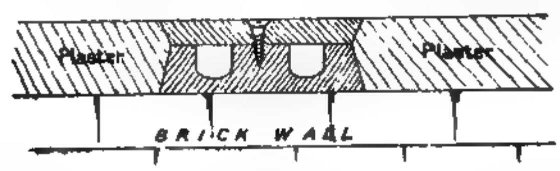
A vessel, B, of a convenient shape, such as a lamp-glass cylinder, is furnished with two well-fitting corks, through each of which passes a leading tube, as in Fig. 16, and the whole is supported by means of two rings on a retort stand, C. The interior of this vessel is about half filled with large pieces of sulphide of iron, which are prevented from falling down into the lower neck by a circular piece of lead, *a*. The tube at the bottom communicates by stout india-rubber tubing with another vessel, A, which contains dilute hydrochloric acid, and this is tied up with cord so that it can be hung up by a loop at different heights, by which means the acid can be brought either into contact with the sulphide of iron or, by lowering, taken away. A clip, *b*, on the delivery pipe serves to regulate the stream of sulphuretted hydrogen, and the corks, preferably india-rubber, should fit extremely well so as to prevent either leakage of gas or acid.

A more convenient form of apparatus, though one which cannot be fit up so cheaply as the latter, is shown in Fig. 17.

It consists of a chloride of calcium tower, A, containing lumps of sulphide of iron in its upper portion, and the lower part of which is connected to a tubulated bottle, B, containing the dilute acid, the latter being raised or lowered for starting or stopping the current by supporting it on blocks of wood as shown. The corks should in this case also be well-fitting, otherwise accidents may easily occur, resulting in the loss of acid.

KEYED CASING AND COVER FOR ELECTRIC LIGHT WIRES.

We have recently had brought to our notice a new design in electric light casings which has been registered by Mr. Geo. G. Sarney, of 145, Mayall-road, Herne Hill, S.E. From the accompanying illustration it will be seen that when the casing is used on the walls of buildings, and fixed flush with the plaster, the capping forms a key to it. When so fixed should it be necessary to look to or alter the wires, the capping can easily be removed without breaking away the edges of the plaster. In new buildings in the course of erection it can be used as a ground for plasterers to gauge to. This device should also prove extremely useful and economical to contractors wiring buildings when the plastering is finished, because the chases cut in the walls, etc., can be cut so much smaller than when the ordinary casing is used. Ordinary types of casing offer no support



to the plaster used for making good, and this means a mass of material must be put on to get it to adhere properly to the plaster on the walls, and naturally a larger chase must be cut. The keyed edge of this casing does support the plaster, and therefore the use of a smaller chase and less material, thereby considerably reducing the cost of cutting away and making good.

Primary Batteries.—The extension of electrical applications in all directions has led many to give continued attention to the cheapening not only of large but of small generating plants. In one direction we see primary batteries giving place to accumulators, as in the large telegraph station, while in others primary batteries are being strongly advocated as a sufficiently cheap method of production. The competition inaugurated by *L'Elettricita*, of Milan, for the best primary battery, with a prize of 2,000f., has received notice in nearly every technical paper, and is worthy of attention by those who have been working in this direction. The prize battery should at least be able to produce the kilowatt-hour at a price not exceeding one lira, or tenpence. It should not require supervision in action, should not fall in potential more than 5 per cent. in 48 hours, and should not give off bad gases or smell. Thermopiles are admitted, it appears. T[illegible] closes at the end of August.

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THE PACIFIC CABLE.

Our readers are familiar with the fact that for some years past a determined attempt has been made to extend telegraphic communication from our North American colonies by a Pacific cable to our Australian colonies. They also know that the Australian colonies are at present dependent upon the Eastern Extension and the Eastern Telegraph Company for such communication. These companies have driven the hardest possible bargain with the Australian group of colonies, and when agreements have come to an end, have played off one colony against another to obtain their own ends. The Eastern Extension and the Eastern Company are really one concern, worked by one set of officials, but with two sets of directors, the reason for which no man knoweth, unless it is to get a double amount of directors' fees—principally for the same men—and to put friends into directorships wherein they may take fees. Of course, it is the aim of the managers of these companies to retain the monopoly they now hold, and one of the methods in vogue is to manufacture public opinion. The consensus of expression of opinion in the public press is of immense weight only so long as it is known or thought to be independent. In times gone by, when the monopoly was threatened, it was customary to excite the popular imagination by appeals through the press, as the following extracts from the history of the 1884-1886 agitation will show. Both here and in the colonies a considerable amount of labour was gone through in educating the newspapers in the way they were required to go. Take the agreements with New Zealand and New South Wales, which ended in February, 1886. As early as November, 1884, Mr. John Pender commenced his crusade and to put pressure on these colonies. Negotiations did not go quite smoothly, and we find some very peculiar expressions used towards Sir Julius Vogel, then Commissioner of Telegraphs in New Zealand. Here is a sentence taken from a communication of Mr. Pender's to Vogel, 31st March, 1886: "You negotiated and arranged the terms for present cable between New Zealand and Australia, and *know why the cost was so much in excess* of what a cable could be laid for to-day." The italics are ours. Is it an insinuation of something underhand, or what? Vogel replies 2nd April, 1886, that "he does not know why the cost of the cable was . . so much in excess of what the cable could be laid for to-day, and he would be glad of an explanation of the cause to which you refer." No explanation was forthcoming, except the following on 6th April, 1886, "The Postmaster-General having negotiated the contract for the existing cable is as well acquainted with all the details as I am." As outsiders, we read this as a miserable innuendo, and when met with a point-blank request for explanation there is a quick climb down. The negotiations go on, but not satisfactorily so far as Pender is concerned, and so he brings other guns to bear. Public opinion is to be roused, and his agents proceed to accomplish the task set them. Here is the result. Tasmanian agent, 28th Sept., 1886 : "Chamber of Commerce and leading

merchants promise to do utmost." Sydney agent, 4th October, 1886: "I have telegraphed all this to Browning, for New Zealand Press." Adelaide agent, 4th October, 1886: "Correspondence sent to papers on Saturday." Tasmanian agent, 6th October, 1886: "Victoria will have nothing to do with Pacific scheme. Chairman's wish noted. Will keep you well informed." From same, 13th October, 1886: "*Argus* will publish an article on the correspondence with Vogel this week." Melbourne agent, 20th October, 1886: "Ask chairman to wire thanks to the editor of the *Argus* and *Age* for able leaders." There is a singularity in Pender's letters of 20th October, 1886, which may be noted. To Vogel he says: "I should feel obliged if you would give me an early reply to the above proposal," while to the Postmaster-General of New South Wales and Victoria he writes: "Regret the decision of the New Zealand Government not to reopen negotiations." On the 21st October the Sydney agent evidently knows a lot about an unpublished and, in fact, an unpresented report. He says: "Government are considering Pacific scheme which proposes transmitting Government telegrams free up to amount of subsidy. Cracknell will report dead against it, but has to give total cost to this colony for Government telegrams last year. This is £10,800, and will create a sensation." The New Zealand agent on 27th October, 1886, says: "Wellington papers reviewing leader from *Argus* say, 'admire cleverness and activity with which the company are working up public opinion in Australia in their favour.'"

We have said enough to show the importance the present holders of the monopoly pay to the Pacific cable scheme, and it may be taken for granted they will in the first place try all they know to ruin it, and if this is found impossible, to move heaven and earth to get the control of it. From past experience, the Colonies and the other Governments interested should fully understand the energy of the opposition of the men with whom they have to deal.

THE FRENCH ELMORE.

The report of the French Elmore Company will be found elsewhere in our columns. It is unsatisfactory reading, the principal object being to obtain more money from a confiding public. We confess to an utter inability to understand the complicated workings of finance. We confess to an utter inability to understand the argument and report of M. Secrétan, upon which it is hoped to get this extra money. Plain business men, estimating for a maximum output of 300 tons monthly, would be quite satisfied with laying out the factory for an immediate output of 80 tons monthly, with provision to extend as orders came in and the output provided was reached. So far as we can gather, M. Secrétan takes the view that immediately work is commenced an output of 300 tons will be required. It is usually found, however, that orders do not come so easily, and that some time elapses before the full capacity of a works is reached. If the total requirements for France reach 18,000 tons, it can hardly be expected that one-fifth of the orders will immediately be diverted from present channels to the new concern. It is easy to say the results of tests warrant the belief in a large ultimate demand, but buyers want to see the teaching of experience rather than the teaching of expert evidence. We are of the opinion that M. Secrétan ought to have been satisfied with a first equipment for 80 tons output, and the directors ought not to have permitted so great a departure from their original programme. As it is, their capital is gone before they have commenced production, and unless they can obtain more capital the company will be wholly unable to continue operations on a scale sufficiently large to bring in satisfactory returns. M. Secrétan's figures may be perfectly correct—they are not warranted by judicious finance, and ought not to be accepted as proof by investors. They are no proof that the company can command the business estimated.

CORRESPONDENCE.

'One man's word is no man's word,
Justice needs that both be heard.'

WIRING HOUSES.

SIR,—Referring to your leader in your issue of the 15th inst., respecting the hesitancy of householders having little or no interest in their holdings to incur the expense of putting in electric light fittings, seeing that such fittings as usually laid in a house come under the heading of fixtures, and as such therefore become the property of the landlord on the expiry of the lease, will you kindly allow us to point out that we think it quite practical to fall in with your suggestion in dealing with such a state of things—that is, to install the electric light in such a way that the wire, fittings, etc., may not be considered fixtures, and could be readily removed without injury to the house itself.

Some two years ago we were consulted as to fitting up a house in a remote district under these conditions. Our client had not a sufficient interest in the premises to warrant an expenditure of £400 or £500 in case the plant should be considered as a fixture; but if the thing could be done in such a way as to be removable without damage to the house, we might undertake the work.

We did undertake the work, and succeeded in installing about 50 lamps in such a manner that we obtained the landlord's opinion to the effect that he saw no reason to regard the fittings, etc., as fixtures.

The dynamo and engine were, of course, erected in an out-office, and having got our cable through the frame of a window we divided it, bringing one branch to basement, and the other to bedroom floor. We then carried these branches round hall and corridors in casing laid as near the ceiling as possible, and from these, brought branch wires through holes in the partitions (usually lath and plaster) to a ceiling rose attached to the interior surface of the wall. From this rose we trailed a flexible cord along the ceiling through brass hooks, screwed into the joists, to the point where the light was required, where the flexible was simply bent round a hook and held the lamp. From the same ceiling rose a second flexible cord was hung, which carried on its free end an ordinary bedside switch.

Thus we dispensed with casing of any kind in all the apartments, as also the screwing up of switches and ceiling roses, etc. Nor does the appearance of the flexible passing under the ceiling form any eyesore. We also avoided the necessity of lifting a single board throughout the premises.

In conclusion, we may mention the installation has given no trouble since.—Yours, etc.,

J. K. FAHIE AND SON, MM.I.E.E.

9, Westland-row, Dublin,
19th April, 1892.

THE ELECTRIC MOTOR: A PRACTICAL DESCRIPTION OF THE MODERN DYNAMO MACHINE, MORE PARTICULARLY AS A MOTOR.*

BY W. B. SAYERS.

(Concluded from page 378.)

The Dynamo Machine as a Generator.—In writing the present paper, it seemed to me to be better to describe the dynamo machine in the first instance as a motor, and having now attempted to do so, the transition to the consideration of it as a generator is very simple. Imagine the direction of the current and the polarity of the magnets to remain as shown in Fig. 3, but that instead of electric energy being supplied through the mains, F+, F−, the armature is driven by mechanical power against the forces indicated by the curved arrows on the periphery; the dynamo then becomes a generator. The brushes would bear upon the commutator in the same position as that for a motor, but as the direction of rotation is reversed, the slope of the brushes would have to be reversed also.

Again, suppose the supply of electric energy to be cut off, and the rotation of the armature maintained by mechanical power; the result would be that the pressure, which in the case of a motor acts against the electric supply or driving current, would now be available to produce a supply current, and the dynamo thus become a generator. In this case the slope of the brushes would remain unaltered, but they would require moving to the position on the opposite side of the centre line, indicated by θ. It will be noted that what I have termed the driving bars now become the driven bars, and they are, if I may so speak, still the vital part of the armature—the part to which the mechanical power has to be transmitted to the shaft, and the part in which the mechanical power or energy of motion disappears, and the electric energy appears.

A recent refinement in the construction of armature bars is that introduced by Messrs. Crompton and Co. in their larger machines, and consists in making the bars of a twisted strand of copper wires, which are forced by hydraulic pressure into a mould of rectangular section, so as to make a mass almost equal to the density of solid copper by flattening each wire against its neighbour. This construction has led to considerable improvement in the efficiency, and at the same time to reduced heating of smooth-core armatures.

The explanation of this result is as follows: While a conductor or copper bar is moving in an uniform magnetic field, as, for instance, in the centre of the air space, Fig. 1, the electric pressure, or E.M.F., generated in it is the same between any two right-angle planes in the section of the bar, that is, there is an uniform tendency for a current to flow from one end of the conductor to the other. When, however, one part of the conductor in its sideway motion reaches into, say, a weaker part of the field—as when the bar, Fig. 1, should have moved so as to protrude partly from the air space—a lesser pressure will be generated in the part in the weaker field—that is, there will be a greater pressure along one side of the bar than along the other, with the result that a reverse current will flow in the part of the bar which is in the weaker field, and an augmented current in the part which is still in the stronger part of the field. This current will consume energy which will appear in the form of heat in the bar. Now the reverse current must cross from the high-pressure to the low-pressure side of the bar, and in doing so it will have to pass from one wire to the other in the case of the compressed wire bar, and not only will it have to cross from one side to the other, but on account of the twist of the strand, this reversed current will be continually changing from one wire to another, because it will necessarily flow through the low-pressure side of the bar. Now, although the electrical resistance through the contact surface between one wire and its neighbour might not strike one as being very great, probably the surfaces in actual contact at any moment are only a fraction of the whole; and, at any rate, in reality the resistance is enormous as compared with the resistance through solid metals, and these wasteful currents are reduced to a minimum, and practically got rid of. I am indebted to Messrs. Crompton and Co., who have been good enough to send me these bars to show you to-night.*

I may say, further, that when the bars or driving wires are put into slots cut in the iron core of the armature—a practice which is steadily coming into vogue—the advantage gained from making the bars in this way disappears, on account of the fact that the magnetic field in a deep slot cut in wrought iron is sensibly constant, and a bar which is embedded in such a slot, therefore, cannot have a difference of pressure between its two sides.

I shall conclude my paper by giving the chief characteristic features of: I., constant-current or "series" motors; II., constant-pressure or "shunt" motors; and, in doing so, I shall touch upon one or two points which it is very important to know in practice:

Constant-Current or "Series" Motors.

I. A constant-current or series motor will maintain a constant torque at all speeds, and in consequence will do work in proportion to the speed at which it is allowed to run.

II. The amount of backward lead required to be given to the brushes is greater at slow speeds and less at high speeds.

III. A constant-current motor will suffer no harm from being brought to a standstill from a mechanical cause external to the motor, unless the damage is caused from the shock of suddenly arrested motion.

IV. A series motor, if properly designed for the pressure, may be run from constant-pressure supply. Under these conditions it will neither maintain a constant torque nor a constant speed with varying load. If, however, the load is constant, or nearly so, a series motor may often be advantageously used when the supply is a constant-pressure one.

Constant-Pressure or "Shunt" Motors.

I. A shunt motor will run at a nearly constant speed for all loads. It may be compounded so as to run practically constant.

II. The amount of backward lead required to be given to the brushes is least with no load, and increases as the load increases.

III. The speed cannot be varied, unless through a small range, while maintaining the efficiency of the motor.

IV. In starting a shunt motor from a constant-pressure supply the connections must be made in the following order: first, the shunt or magnet wires must be connected to the mains so as to excite the magnets; second, the armature circuit or brushes should be connected first through a resistance coil, which can be cut out of circuit when a moderate speed has been obtained. If the first rule were not complied with, and the armature circuit "switched" on before the magnet circuit, the result would be that a dangerously heavy current would flow through the armature winding, while exerting very little torque, due to the non-existence of the necessary magnetic field in the air space, and the brushes and commutator might be burned and damaged. If the second rule were not complied with, the result would be that a very heavy current would flow, until the speed and consequent back pressure checked it, and the shock to the armature, due to the abnormally heavy torque which would be suddenly applied, might be sufficient to destroy it. In practice the starting switch is designed so as to make the connections in the order given—a suitable resistance being arranged in connection with the switch. The connection to the supply is made through short lengths of fusible metal, the cross-section of which is such that if the current exceeds a predetermined value the heat generated will fuse the metal and disconnect the motor from the mains. These "fuses," as they are called, secure a perfect safeguard against damage to motor in either of the ways mentioned, and they should always be used.

* Paper read before the Institution of Engineers and Shipbuilders in Scotland.

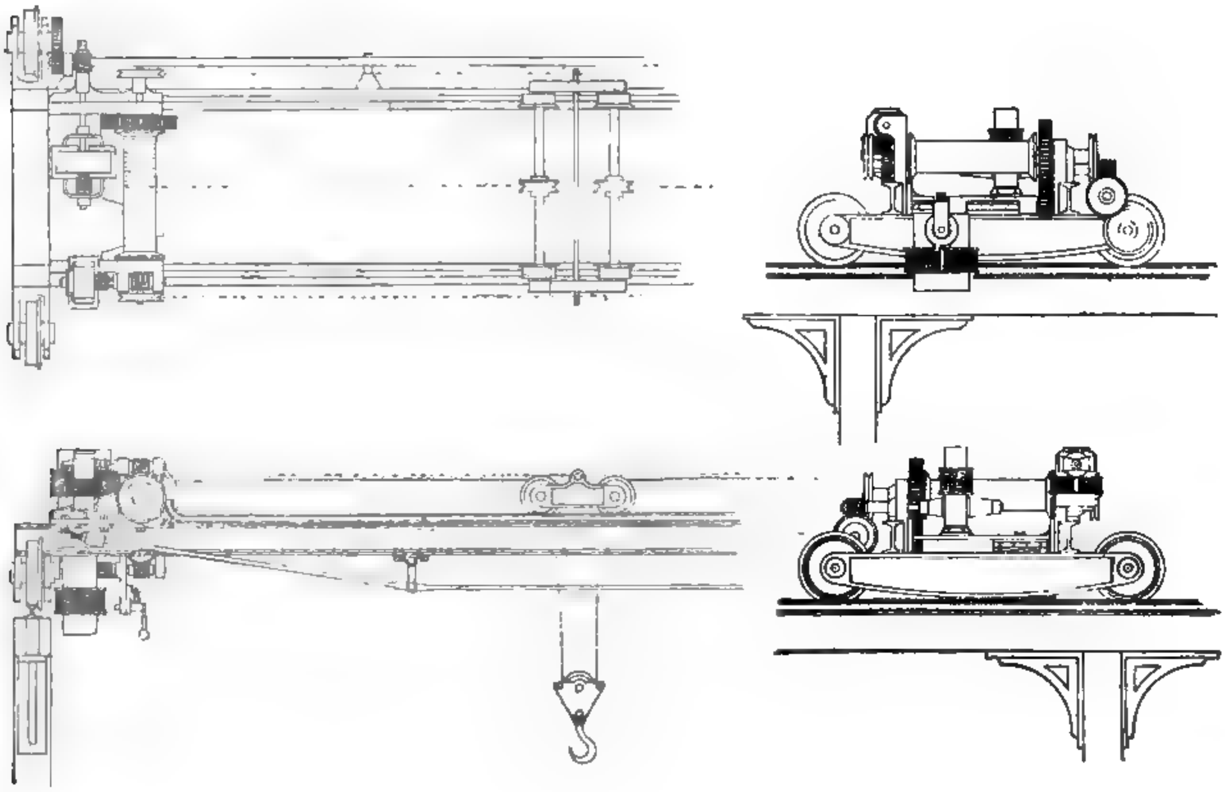
* The bars shown measured about 0·24in. × 0·28in. in cross-section, and were about 13½in. long in the useful part of their length. They would be capable of carrying from 60 to 120 or more amperes, and in a field of 5,000 C.G.S. units (a usual figure) would exert a force of about 2¼lb. with 60 amperes, and 5lb. with 120 amperes, and so on.

ELECTRIC TRAVELLING CRANES.

The convenience of electric motors for cranes and hoists by reason of their ready manipulation is so apparent that it is not surprising to find their use constantly extending. Amongst those who have made this branch of electrical engineering a speciality, Mr. W. D. Sandwell, of Victor Works, Holloway, has erected several successful electric crane plants. Some of these we have already described, and other overhead travelling cranes erected at Bermondsey have given every satisfaction. These have been working for 11 months, and have until the present cost nothing for repairs. The power is supplied by a Sandwell three-unit dynamo, driven by a Soho engine running at 350 revolutions, the speed of the dynamo being 1,500 revolutions. The pressure is 110 volts.

The overhead electric traveller, of which we give illustrations, has been designed for use in a saw-mill at King's Cross, and will be driven by a Sandwell six-unit dynamo wound for 200 volts. The loads for which it is required are all timber, and it will, by a special arrangement, take anything at one hoisting up to a full St. Petersburg standard direct from a van beneath it, and carry it to the machine saw. The traveller is interesting from the fact that three motors are provided, one for each movement. After trials of all sorts of gear for manipulating a crane, it has been found that the extra motors are by far the cheapest and most efficient, and require also less skilful driving than any other arrangement to be adopted, besides taking a smaller maximum current to drive. The crane has been designed for a load of two tons and a span of 30ft. It has hoisting, travelling, and traversing motions, and the height from the bottom of girder to the top of machinery is only 25in., making it available in places where space is valuable.

Two of these travellers have been working in an ice factory for the last year, and though always covered with condensed steam have been found to give every satisfaction. The electric cranes at the wharf in the City-road, which we described some time ago, have now had the electric light added, the plant consisting of six-unit dynamo supplying 70 lights from 8 c.p. to 100 c.p. The power plant at this installation, we are told, has not cost a penny for repairs since first it was put down two years ago.



Sandwell's Electric Travelling Crane.

ELECTRICAL TESTING INSTRUMENTS.

We recently noticed the catalogue of measuring instruments issued by Messrs. Nalder Bros. and Co., of Red Lion-street, E.C. We have now before us a very comprehensive catalogue, by the same firm, of electrical testing instruments. These are more particularly for telegraph and cable testing, experimental, laboratory, and research work. Condensers and quadrant electrometers are first mentioned and illustrated; and a large variety of the best-known forms of galvanometer occupy a large portion of the pamphlet. Detector, astatic, tangent, and other galvanometers—a very useful form being a type of D'Arsonval-Deprez dead-beat testing galvanometer, not expensive, and very suitable for testing laboratories. Reflecting galvanometers of various patterns are shown with all appurtenances, scales, lamps, keys, and so forth, in convenient shape. The firm are makers of a number of special instruments, amongst which may be mentioned Profs. Ayrton and Perry's secohmmeter, their variable standard of self-induction reading direct in millihenrys; Prof. Forbes's thermo-galvanometer; Prof. Thompson's standard spherometer; Mr. Llewellyn Smith's integraph for graphical determination of problems in connection with alternating-current machines and other instruments. They show a large number of college instruments and sets of apparatus, besides resistance-boxes, cells, keys, and testing sets.

Occlusion of Hydrogen.—Some interesting experiments have recently been carried out by MM. Bellati and Lussarra in connection with the occlusion of hydrogen by nickel. The experiments were carried out with nickel wires used as the negative electrodes of a voltameter. After a current has been passed through the voltameter for 200 hours, one of these wires was found to have absorbed about 100 volumes of hydrogen. The occluded hydrogen was not given off freely. On the contrary, the wires became oxidised on exposure to the air. While the process of occlusion was going on, it was found that the wire elongated in 11 days by 0·00036 of its length. The resistance of the nickel increased as occlusion proceeded, the temperature coefficient meantime diminishing.

THE WESTON VOLTMETERS AND AMMETERS.

BY H. MASCHKE, PH.D.

(*Continued from page 382.*)

Special Remarks About the Weston Voltmeters.—The different types of the Weston voltmeters and millivoltmeters may be seen from the following table :

Voltmeters.

No.	Scale.	Value of one scale division.	Capable of being read to :	Approximate resistance.	Remarks.
	Volts.	Volt.	Volt.		
1......	0–150	1	1/10	18,000 ohms	[calibrating coil.
2......	0–150	1	1/10	18,000 ,,	Contact key and
3... {	0–150	1	1/10	18,000 h.v.c	Contact key.
	0–5	1/30	1/300	600 l.v.c.	—
4... {	0–150	1	1/10	18,000 h.v.c.	Contact key.
	0–15	1/10	1/100	1,800 l.v.c.	[calibrating coil.
5... ..	0–300	2	1/5	36,000 ohms	Contact key and [calibrating coil.
6......	0–450	3	1/3	54,000 ,,	Contact key and
7......	0–600	5	1/2	72,000 ,,	[calibrating coil.
8... ..	0–600	5	1/2	72,000 ,,	Contact key and
9... {	0–600	4	1/2	72,000 h.v.c.	—
	0–150	1	1/10	18,000 l.v.c.	Contact key.
9½ {	0–750	5	1/2	90,000 h.v.c.	—
	0–150	1	1/10	18,000 l.v.c.	Contact key.
10... {	0–600	4	1/2	72,000 h.v.c.	—
	0–300	2	1/5	36,000 l.v.c.	Contact key.
11.. ..	0–750	5	1/2	90,000 ohms	—
12......	0–1,500	10	1	180,000 ,,	—

H.v.c. : High-volt coil. L.v.c. : Low-volt coil.

The instruments Nos. 3, 4, 9, 9½, and 10 are supplied with a double scale.

High-Range Voltmeters.—Each of these instruments consists of a No. 1 voltmeter with a separate box containing a certain resistance. The values of the scale divisions must then be multiplied by a certain number given in the following table when the instrument and the resistance-box are connected in series. The scale is divided into 150 divisions, and if used without the resistance-box the instrument serves simply as a No. 1 voltmeter.

No.	Range.	Multiplying power of the resistance-box.	Capable of being read to	Resistance.
13	0–2,250 V.	15	1½ volts.	270,000 ohms.
14	0–3,000 ,,	20	2 ,,	360,000 ,,
15	0–3,750 ,,	25	2½ ,,	450,000 ,,
16	0–4,500 ,,	30	3 ,,	540,000 ,,
17	0–5,250 ,,	35	3½ ,,	630,000 ,,
18	0 6,000 ,,	40	4 ,,	720,000 ,,

Millivoltmeters.

No.	Scale.	Value of one scale division.	Capable of being read to :	Approx. resistance.	—
	Volt.	Volt.	Volt.	Ohm.	
1	0–1/50	1/5000	1/50000	½	
2	0–1/100	1/10000	1/100000	½	Zero in the centre of the scale ; 100 divisions right and left.
3 {	0–1/100	1/10000	1/100000	½	Zero in the centre ; contact key reducing the sensibility ten times.
	0–1/10	1/1000	1/10000	5	

The instruments are all constructed in the same way, except the millivoltmeters, in which the movable coil is wound differently. They differ only in the amount of resistance inserted in the circuit in series with the coil. These additional resistance coils are located concentrically with each other underneath the scale-plate ; in the instruments intended for the highest voltage they are placed in a neat separate box accompanying the instrument.

For the voltmeters, furnished with a double scale or with a calibrating coil, two binding screws are provided for the negative wire.

If connected to the rear binding screw of a double-scale instrument, the readings are to be taken on the lower scale. If, however, connection is made to the front binding screw additional resistance coils of the apparatus are inserted in circuit and the upper scale is to be used.

If the largest resistance added to the instrument in a separate box is used, readings can be taken up to 6,000 volts. On the other hand, the smallest pressure to be read with the millivoltmeter is 0·00001 volt.

The value of the resistance of the voltmeter measured exactly to one hundredth of an ohm at 70deg. F. is marked on every instrument.

Special Remarks About the Weston Ammeters.—The ammeters are identical with the voltmeters as far as the appearance of the apparatus, the construction of the magnetic field, the movable coil, etc., are concerned. They differ only in that respect that a shunt is provided within the instrument through which the current to be measured is conducted, and to the ends of which the wires leading to the movable coil are connected. The construction of the shunt is such that the current passing through the same can by no means directly affect the magnetic field. It consists of two copper plates separated by a thin insulating layer, which are located in the space left vacant by the magnet, and connected directly to the two binding screws situated on the right-hand side of the ammeter.

These copper plates are connected with each other by a certain number of insulated wire coils arranged in multiple arc, the winding being conducted round the magnet in such a manner that every two neighbouring wires are passed by the current in opposite directions.

Ammeters.

No.	Scale.	Value of one scale division.	Capable of being read to:	Approximate resistance.
	Amperes.	Amperes.	Amperes.	
1	0– 5	1/20	1/200	0·007
2	0– 15	1/10	1/100	0·0022
3	0– 25	¼	1/40	0·0013
4	0– 50	½	1/20	0·00066
5	0–100	1	1/10	0·00033
6	0–150	1	1/10	0·00022
7	0–200	2	1/5	0·00016
8	0–250	2	1/5	0·00013
9	0–300	2	1/5	0·00011

Milliammeters.

No.	Scale.	Value of one scale division.	Capable of being read to:	Approximate resistance.
	Milliamperes.	Milliamperes.	Milliamperes.	
0	0–150	1	1/10	0·22
1	0–300	2	1/5	0·11
2	0–600	5	½	0·055
3	0–1,000	10	1	0·033
4	0–1,500	10	1	0·022
5 {	0–500	5	½	0·066
	0–50	½	1/20	0·66
6 {	0–500	5	½	0·19
	0–10	1/10	1/100	10·5

The instruments Nos. 5 and 6 have a double scale.

The resistance of the shunt is adjusted in ammeters and milliammeters so as to produce a drop of potential of about 0·03 volt when the strongest current allowable for the instrument is applied. The resistance of the movable coil and the two springs is 0·5 ohm. While the instruments intended for strong currents read up to 300 amperes, the milliammeters will measure a current of 0·00001 ampere.

HEDGEHOGS AND SNAKES.

A poetical-looking visitor of serene manner was observed making careful enquiries of the electrical engineer in the Prince's Room, Crystal Palace, at the time of Messrs. Swinburne's high-tension experiments. A programme with the following was afterwards picked up by an attendant :

On Teddington's fair banks a snake is bred,
With curling crest and with advancing head ;
Waving he rolls and makes a sinuous track,
His belly hollow, rounded is his back.
With swift commotions to and fro he reels,
And surges alternate his body feels,
Fire-spitting, venomous, with deadly bite,
He yet, when gently urged, gives glowworm light.
His home an earthen pan, tight covered in,
Vainly disputed with a hedgehog thin,
Who bristling, alert, with stiffened spines,
Doth chase the snake forth from the sad confines.
Angry and hissing, who can stay his darts ?
On every side his fiery power starts.
Lurid, his forkèd tongues and breath of flame
Dart o'er the surface of a window pane,
And horrid crashings of unruly power,
With writhing arms in lightning torrents shower.
No solid substance can control its force—
At one fell stroke the power of forty-horse.
Death and destruction lurk within its coil,
Till, like the Forty Thieves, 'tis boiled in oil,
The volty power controlled without a hitch,
Like a caged lion—by boldness and a switch.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

I cannot find words to express how deeply I feel the honour of addressing some of the foremost thinkers of the present times, and so many able scientific men, engineers, and electricians, of the country greatest in scientific achievements. The results which I have the honour to present before such gathering I cannot call my own. There are among you not a few who can lay better claim than myself on any feature of merit which this work may contain. I need not mention many names which are world known—names of those among you who are recognised as the leaders in this enchanting science; but one, at least, I must mention—a name which could not be omitted in a demonstration of this kind. It is a name associated with the most beautiful invention ever made: it is Crookes!

When I was at college, a good time ago, I read, in a translation (for then I was not familiar with your magnificent language), the description of his experiments on radiant matter. I read it only once in my life—that time—yet every detail about that charming work I can remember this day. Few are the books, let me say, which can make such an impression upon the mind of a student. But if on the present occasion I mention this name, as one of many your Institution can boast of, it is because I have more than one reason to do so. For what I have to tell you and to show you this evening concerns in a large measure that same vague world which Prof. Crookes has so ably explored; and, more than this, when I trace back the mental process which led me to these advances—which even by myself cannot be considered trifling, since they are so appreciated by you—I believe that their real origin, that which started me to work in this direction, and brought me to them after a long period of constant thought, was that fascinating little book which I read many years ago.

And now that I have made a feeble effort to express my homage and acknowledge my indebtedness to him and others among you, I will make a second effort, which I hope you will not find so feeble as the first, to entertain you. Give me leave to introduce the subject in a few words. A short time ago I had the honour to bring before our American Institute of Electrical Engineers some results then arrived at by me in a novel line of work. I need not assure you that the many evidences which I have received that English scientific men and engineers were interested in this work, have been for me a great reward and encouragement. I will not dwell upon the experiments already described, except with the view of completing, or more clearly expressing, some ideas advanced by me before, and also with the view of rendering the study here presented self-contained, and my remarks on the subject of this evening's lecture consistent. This investigation, then, it goes without saying, deals with alternating currents, and, to be more precise, with alternating currents of high potential and high frequency. Just in how much a very high frequency is essential for the production of the results presented, is a question which, even with my present experience, would embarrass me to answer. Some of the experiments may be performed with low frequencies, but very high frequencies are desirable, not only on account of the many effects secured by their use, but also as a convenient means of obtaining, in the induction apparatus employed, the high potentials which, in their turn, are necessary to the demonstration of most of the experiments here contemplated.

Of the various branches of electrical investigation, perhaps the most interesting and immediately the most promising is that dealing with alternating currents. The progress in this branch of applied science has been so great in recent years that it justifies the most sanguine hopes. Hardly have we become familiar with one fact when novel experiences are made, and new avenues of research are opened. Even at this hour possibilities not dreamt of before are, by the use of these currents, partly realised. As in Nature all is ebb and tide, all is wave motion, so it seems that in all branches of industry alternating currents—electric wave motion—will have the sway. One reason, perhaps, why this branch of science is being so rapidly developed is to be found in the interest which is attached to its experimental study. We wind a simple ring of iron with coils; we establish the connections to the generator, and with wonder and delight we note the effects of strange forces which we bring into play, which allow us to transform, to transmit and direct energy at will. We arrange the circuits properly, and we see the mass of iron and wires behave as though it were endowed with life, spinning a heavy armature, through invisible connections, with great speed and power—with the energy possibly conveyed from a great distance. We observe how the energy of an alternating current traversing the wire manifests itself—not so much in the wire as in the surrounding space—in the most surprising manner, taking the forms of heat, light, mechanical energy, and, most surprising of all, even chemical affinity. All these observations fascinate us, and fill us with an intense desire to know more about the nature of these phenomena. Each day we go to our work in the hope of discovering—in the hope that someone, no matter who, may find a solution of one of the pending great problems—and each succeeding day we return to our task with renewed ardour; and even if we are unsuccessful, our work has not been in vain, for in these strivings, in these efforts, we have found hours of untold pleasure, and we have directed our energies to the benefit of mankind.

We may take—at random, if you choose, any of the many experiments which may be performed with alternating currents; a few of which only, and by no means the most striking, form the subject of this evening's demonstration; they are all equally interesting, equally inciting to thought. Here is a simple glass tube from which the air has been partially exhausted. I take hold of it; I bring my body in contact with a wire conveying alternating currents of high potential, and the tube in my hand is brilliantly lighted. In whatever position I may put it, wherever I may move it in space, as far as I can reach, its soft, pleasing light persists with undiminished brightness. Here is an exhausted bulb suspended from a single wire. Standing on an insulated support, I grasp it, and a platinum button mounted in it is brought to vivid incandescence. Here, attached to a leading wire, is another bulb, which, as I touch its metallic socket, is filled with magnificent colours of phosphorescent light. Here still another, which by my fingers' touch casts a shadow—the Crookes shadow of the stem inside of it. Here, again, insulated as I stand on this platform, I bring my body in contact with one of the terminals of the secondary of this induction coil—with the end of a wire many miles along—and you see streams of light break forth from its distant end, which is set in violent vibration. Here, once more, I attach these two plates of wire gauze to the terminals of the coil, I set them a distance apart, and I set the coil to work. You may see a small spark pass between the plates. I insert a thick plate of one of the best dielectrics between them, and instead of rendering altogether impossible, as we are used to expect, I aid the passage of the discharge, which, as I insert the plate, merely changes in appearance and assumes the form of luminous streams. Is there, I ask, can there be, a more interesting study than that of alternating currents?

In all these investigations, ladies and gentlemen, in all these experiments, which are so very, very interesting, for many years past—ever since the greatest experimenter who lectured in this hall discovered its principle—we have had a steady companion, an appliance familiar to everyone, a plaything once, a thing of momentous importance now—the induction coil. There is no dearer appliance to the electrician. From the ablest among you, I dare say, down to the inexperienced student, to your lecturer, we all have passed many delightful hours in experimenting with the induction coil. We have watched its play, and thought and pondered over the beautiful phenomena which it disclosed to our ravished eyes. So well known is this apparatus, so familiar are these phenomena to everyone, that my courage nearly fails me when I think that I have ventured to address so able an audience, that I have hazarded to entertain you with that same old subject. Here in reality is the same apparatus, and here are the same phenomena, only the apparatus is operated somewhat differently, the phenomena are presented in a different aspect. Some of the results we find as expected, others surprise us, but all captivate our attention, for in scientific investigation each novel result achieved may be the centre of a new departure, each novel fact learned may lead to important developments. Usually in operating an induction coil we have set up a vibration of moderate frequency in the primary, either by means of an interruptor or break, or by the use of an alternator. Earlier English investigators, to mention only Spottiswoode and J. E. H. Gordon, have used a rapid break in connection with the coil. Our knowledge and experience of to-day enables us to see clearly why these coils, under the conditions of the tests, did not disclose any remarkable phenomena, and why able experimenters failed to perceive many of the curious effects which have since been observed. In the experiments such as performed this evening, we operate the coil either from a specially-constructed alternator capable of giving many thousands of reversals of current per second, or, by disruptively discharging a condenser through the primary, we set up a vibration in the secondary circuit of a frequency of many hundred thousands or millions per second, if we so desire; and in using either of these means we enter a field as yet unexplored.

It is impossible to pursue an investigation in any novel line without finally making some interesting observation or learning some useful fact. That this statement is applicable to the subject of this lecture the many curious and unexpected phenomena which we observe afford a convincing proof. By way of illustration take, for instance, the most obvious phenomena, those of the discharge of the induction coil. Here is a coil which is operated by currents vibrating with extreme rapidity, obtained by disruptively discharging a Leyden jar. It would not surprise a student were the lecturer to say that the secondary of this coil consists of a small length of comparatively stout wire; it would not surprise him were the lecturer to state that, in spite of this, the coil is capable of giving any potential which the best insulation of the turns is able to withstand; but although he may be prepared, and even indifferent as to the anticipated result, yet the aspect of the discharge of the coil will surprise and interest him. Everyone is familiar with the discharge of an ordinary coil; it need not be reproduced here. But, by way of contrast, here is a form of discharge of a coil the primary current of which is vibrating several hundred thousand times per second. The discharge of an ordinary coil appears as a simple line or band of light. The discharge of this coil appears in the form of powerful brushes and luminous streams issuing from all points of the two straight wires attached to the terminals of the secondary. Now compare this phenomenon which you have just witnessed with the discharge of a Holtz or Wimshurst machine—that other interesting appliance so dear to the experimenter. What a difference there is between both these phenomena! And yet, had I made the necessary arrangements—which could have been made easily, were it not that they would interfere with other experiments, I could have produced with this coil sparks which, had I the coil had [illegible] two knobs exposed, even

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

the keenest observer among you would find it difficult, if not impossible, to distinguish from those of an influence or friction machine. This may be done in many ways—for instance, by operating the induction coil which charges the condenser from an alternating-current machine of very low frequency, and preferably adjusting the discharge circuit so that there are no oscillations set up in it. We then obtain in the secondary circuit, if the knobs are of the required size and properly set, a more or less rapid succession of sparks of great intensity and small quantity, which possess the same brilliancy, and are accompanied by the same sharp crackling sound as those obtained from a friction or influence machine.

Another way is to pass through two primary circuits, having a common secondary, two currents of a slightly different period, which produce in the secondary circuit sparks occurring at comparatively long intervals. But, even with the means at hand this evening, I may succeed in imitating the spark of a Holtz machine. For this purpose I establish between the terminals of the coil which charges the condenser a long unsteady arc, which is periodically interrupted by the upward current of air produced by it. To increase the current of air I place on each side of the arc, and close to it, a large plate of mica. The condenser charged from this coil discharges into the primary circuit of a second coil through a small air gap, which is necessary to produce a sudden rush of current through the primary. The scheme of connections in the present experiment is indicated in

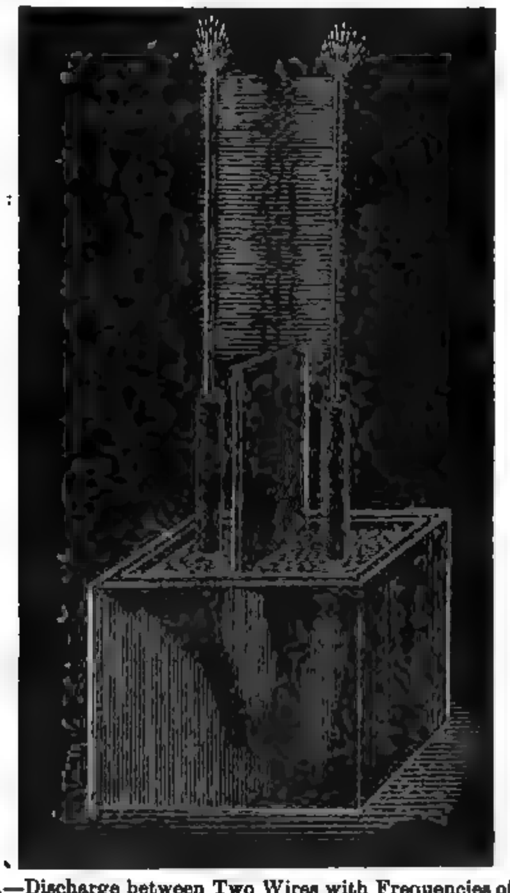


FIG. 1.—Discharge between Two Wires with Frequencies of a Few Hundred Thousands per Second.

Fig. 2 G is an ordinarily constructed alternator supplying the primary, P, of an induction coil, the secondary, S, of which charges the condensers, or jars, C C. The terminals of the secondary are connected to the inside coatings of the jars, the outer coatings being connected to the ends of the primary, $p\,p$, of a second induction coil. This primary, $p\,p$, has a small air gap. $a\,b$. The secondary, s, of this coil is provided with knobs, or spheres, K K, of the proper size, and set at a distance suitable for the experiment. A long arc is established between the terminals, A B, of the first induction coil. M M are the mica plates. Each time the arc is broken between A and B the jars are quickly charged and discharged through the primary, $p\,p$, producing a snapping spark between the knobs, K K. Upon the arc forming between A and B the potential falls, and the jars cannot be charged to such high potential as to break through the air gap, $a\,b$, until the arc is again broken by the draught. In this manner sudden impulses at long intervals are produced in the primary, $p\,p$, which in the secondary, s, give a corresponding number of impulses of great intensity. If the secondary knobs, or spheres, K K, are of the proper size, the sparks show much resemblance to those of a Holtz machine.

But these two effects, which to the eye appear so very different, are only two of the many discharge phenomena. We only need to change the conditions of the test, and again we make other observations of interest. When, instead of operating the induction coil as in the two last experiments, we operate it from a high-frequency alternator, as in the next experiment, a systematic study of the phenomena is rendered much more easy. In such case, in varying the strength and frequency of the currents through the primary, we may observe five distinct forms of discharge, which I have described in my former paper on this subject before the American Institute of Electrical Engineers, May 20, 1891.

It would take too much time, and it would lead us too far from the subject presented this evening, to reproduce all these forms, but it seems to me desirable to show you one of them. It is a brush discharge, which is interesting in more than one respect. Viewed from a near position, it resembles much a jet of gas escaping under great pressure. We know that the phenomenon is due to the agitation of the molecules near the terminal, and we anticipate that some heat must be developed by the impact of the molecules against the terminal or against each other. Indeed, we find that the brush is hot, and only a little thought leads us to the conclusion that, could we but reach sufficiently high frequencies, we could produce a brush which would give intense light and heat, and which would resemble in every particular an ordinary flame, save, perhaps, that both phenomena might not be due to the same agent—save, perhaps, that chemical affinity might not be electrical in its nature. As the production of heat and light is here due to the impact of the molecules, or atoms, of air or of something else besides, and as we can augment the energy simply by raising the potential, we might, even with frequencies obtained from a dynamo machine, intensify the action to such a degree as to bring the terminal to melting heat. But with such low frequencies we would have to deal always with something of the nature of an electric current. If I approach a conducting object to the brush a thinny little spark passes, yet even with the frequencies used this evening the tendency to spark is not very great. So, for instance, if I hold a metallic sphere at some distance above the terminal, you may see the whole space between the terminal and

FIG. 2.—Imitating the Spark of a Holtz Machine.

sphere illuminated by the streams without the spark passing; and with the much higher frequencies obtainable by the disruptive discharge of a condenser, were it not for the sudden impulses, which are comparatively few in number, sparking would not occur even at very small distances. However, with incomparably higher frequencies, which we may yet find means to produce efficiently, and provided that electric impulses of such high frequencies could be transmitted through a conductor, the electrical characteristics of the brush discharge would completely vanish—no spark would pass, no shock would be felt—yet we would still have to deal with an electric phenomenon, but in the broad, modern interpretation of the word. In my first paper before referred to, I have pointed out the curious properties of the brush, and described the best manner of producing it, but I have thought it worth while to endeavour to express myself more clearly in regard to this phenomenon, because of its absorbing interest. When a coil is operated with currents of very high frequency, beautiful brush effects may be produced, even if the coil be of comparatively small dimensions. The experimenter may vary them in many ways, and, if it were nothing else, they afford a pleasing sight. What adds to their interest is that they may be produced with one single terminal as well as with two; in fact, often better with one than with two.

But of all the discharge phenomena observed, the most pleasing to the eye, and the most instructive, are those observed with a coil which is operated by means of the disruptive discharge of a condenser. The power of the brushes, the abundance of the sparks, when the conditions are patiently adjusted, is often

amazing. With even a very small coil, if it be so well insulated as to stand a difference of potential of several thousand volts per turn, the sparks may be so abundant that the whole coil may appear a complete mass of fire. Curiously enough, the sparks, when the terminals of the coil are set at a considerable distance, seem to dart in every possible direction, as though the terminals were perfectly independent of each other. As the sparks would soon destroy the insulation, it is necessary to prevent them. This is best done by immersing the coil in a good liquid insulator, such as boiled-out oil. Immersion in a liquid may be considered almost an absolute necessity for the continued and successful working of such a coil.

It is, of course, out of question, in an experimental lecture, with only a few minutes at disposal for the performance of each experiment, to show these discharge phenomena to advantage, as to produce each phenomenon at its best a very careful adjustment is required. But even if imperfectly produced, as they are likely to be this evening, they are sufficiently striking to interest an intelligent audience. Before showing some of these curious effects I must, for the sake of completeness, give a short description of the coil and other apparatus used in the experiments with the disruptive discharge this evening. It is contained in a box, B, Fig. 3, of thick boards

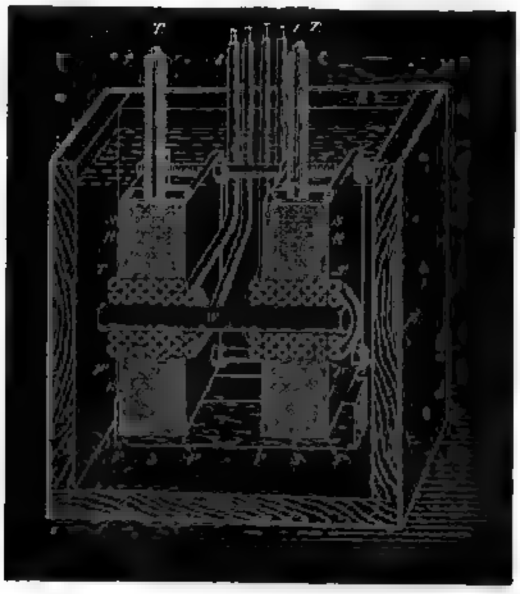


Fig. 3.—Disruptive Discharge Coil.

of hard wood, covered on the outside with zinc sheet, Z, which is carefully soldered all round. It might be advisable, in a strictly scientific investigation, when accuracy is of great importance, to do away with the metal cover, as it might introduce many errors, principally on account of its complex action upon the coil, as a condenser of very small capacity, and as an electrostatic and electromagnetic screen. When the coil is used for such experiments as are here contemplated, the employment of the metal cover offers some practical advantages, but these are of not sufficient importance to be dwelt upon. The coil should be placed symmetrically to the metal cover, and the space between should, of course, not be too small—certainly not less than, say, five centimetres, but much more if possible; especially the two sides of the zinc box, which are at right angles to the axis of the coil, should be sufficiently remote from the latter, as otherwise they might impair its action and be a source of loss. The coil consists of two spools of hard rubber, R R, held apart at a distance of 10 centimetres by bolts, *c*, and nuts, *n*, likewise of hard rubber. Each spool comprises a tube, T, of approximately eight centimetres inside diameter and three millimetres thick, upon which are screwed two flanges, F F, 24 centimetres square, the space between the flanges being about three centimetres. The secondary, S S, of the best guttapercha-covered wire, has 26 layers, 10 turns in each, giving for each half a total of 260 turns. The two halves are wound oppositely and connected in series, the connection between both being made over the primary. This disposition, besides being convenient, has the advantage that when the coil is well balanced—that is, when both of its terminals, T_1 T_1, are connected to bodies or devices of equal capacity—there is not much danger of breaking through to the primary, and the insulation between the primary and the secondary need not be thick. In using the coil it is advisable to attach to both terminals devices of nearly equal capacity, as, when the capacity of the terminals is not equal, sparks will be apt to pass to the primary. To avoid this, the middle point of the secondary may be connected to the primary, but this is not always practicable. The primary, P P, is wound in two parts, and oppositely, upon a wooden spool, W, and the four ends are led out of the oil through hard rubber tubes, *t t*. The ends of the secondary, T_1 T_1, are also led out of the oil through rubber tubes, t_1 t_1, of great thickness. The primary and secondary layers are insulated by cotton cloth, the thickness of the insulation, of course, bearing some proportion to the difference of potential between the turns of the different layers. Each half of the primary has four layers, 24 turns in each, this giving a total of 96 turns. When both the parts are connected in series, this gives a ratio of conversion of about 1 : 2·7, and with the primaries in multiple, 1 : 5·4; but in operating with very rapidly-alternating currents this ratio does not convey even an approximate idea of the ratio of the E.M.F.'s in the primary and secondary circuits. The coil is held in position in the oil on wooden supports, there being about five centimetres thickness of oil all around. Where the oil is not specially needed, the space is filled with pieces of wood, and for this purpose principally the wooden box, B, surrounding the whole is used. The construction here shown is, of course, not the best on general principles, but I believe it is a good and convenient one for the production of effects in which an excessive potential and a very small current is needed. In connection with the coil, I use either the ordinary form of discharger or a modified form. In the former I have introduced two changes which secure some advantages, and which are obvious. If they are mentioned, it is only in the hope that some experimenter may find them of use. One of the changes is that the adjustable knobs, A and B (Fig. 4), of the discharger are held in jaws, J J, of brass by spring pressure, this allowing to turn them successively in different positions and so do away with the tedious process of frequent polishing up. The other change consists in the employment of a strong electromagnet, N S, which is placed with its axis at right angles to the line joining the knobs A and B, and produces a strong magnetic field between them. The pole-pieces of the magnet are movable, and properly formed so as to protrude between the brass knobs, in order to make the field as intense as possible; but to prevent the discharge from jumping to the magnet, the pole-pieces are protected by a layer of mica, M M, of sufficient thickness; s_1 s_1 and s_2 s_2 are screws for fastening the wires. On each side one of the screws is for large and the other for small wires. L L are screws for fixing in position the rods, R R, which support the knobs. In another arrangement with the

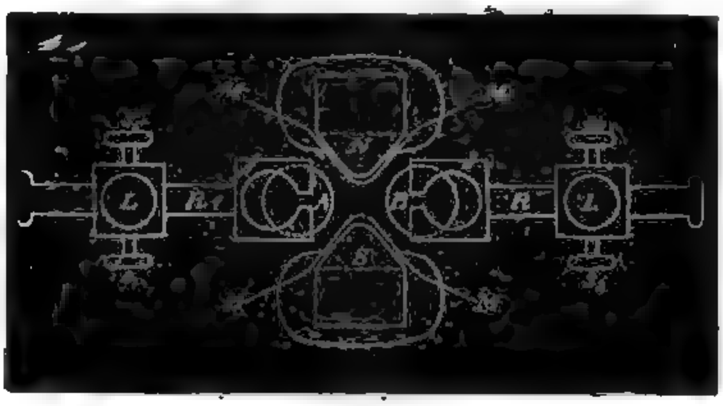


Fig. 4.—Arrangement of Improved Discharger and Magnet.

magnet I take the discharge between the rounded pole-pieces themselves, which in such case are insulated and preferably provided with polished brass caps.

The employment of an intense magnetic field is of advantage principally when the induction coil or transformer which charges the condenser is operated by currents of very low frequency. In such a case the number of the fundamental discharges between the knobs may be so small as to render the currents produced in the secondary unsuitable for many experiments. The intense magnetic field then serves to blow out the arc between the knobs as soon as it is formed, and the fundamental discharges occur in quicker succession. Instead of the magnet, a draught or blast of air may be employed with some advantage. In this case the arc is preferably established between the knobs, A B, in Fig 2 (the knobs *a b* being generally joined, or entirely done away with), as in this disposition the arc is long and unsteady, and is easily affected by the draught. When a magnet is employed to break the arc, it is better to choose the connection indicated schematically in Fig. 5, as in this case the currents forming the arc are much more powerful, and the magnetic field exercises a greater influence.

Fig. 5.—Arrangement with Low-Frequency Alternator and Improved Discharger.

The use of the magnet permits, however, of the arc being replaced by a vacuum tube, but I have encountered great difficulties in working with an exhausted tube.

The other form of discharger used in these and similar experiments is indicated in Figs. 6 and 7. It consists of a number of brass pieces, *c c* (Fig. 6), each of which comprises a spherical middle portion, *m*, with an extension, *e*, below—which is merely used to fasten the piece in a lathe when polishing up the discharging surface—and a column above, which consists of a knurled flange, *f*, surmounted by a threaded stem, *l*, carrying a nut, *n*, by means of which a wire is fastened to the column. The

flange, *f*, conveniently serves for holding the brass piece when fastening the wire, and also for turning it in any position when it becomes necessary to present a fresh discharging surface. Two stout strips of hard rubber, R R, with planed grooves, *g g* (Fig. 7), to fit the middle portion of the pieces, *c c*, serve to clamp the latter and hold them firmly in position by means of two bolts, C C (of which only one is shown), passing through the ends of the strips. In the use of this kind of discharger I have found three principal advantages over the ordinary form. Firstly, the dielectric strength of a given total width of air space is greater when a great many small air gaps are used instead of one, which permits of working with a smaller length of air gap, and that means smaller loss and less deterioration of the metal; secondly, by reason of splitting the arc up into smaller arcs, the polished surfaces are made to last much longer; and thirdly, the apparatus affords some gauge in the experiments. I usually set the pieces, by putting between them sheets of uniform thickness, at a certain very small distance which is known from the experiments of Sir William Thomson to require a certain E.M.F. to be bridged by the spark. It should, of course, be remembered that the sparking distance is much diminished as the frequency is increased. By taking any number of spaces the experimenter has a rough idea of

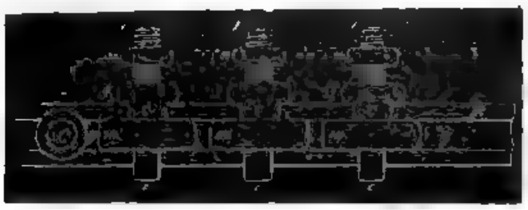


FIG. 6.

the E.M.F., and he finds it also easier to repeat an experiment, as he has not the trouble of setting the knobs again and again. With this kind of discharger I have been able to maintain an oscillating motion without any spark being visible with the naked eye between the knobs, and they would not show a very appreciable rise in temperature. This form of discharger also lends itself to many arrangements of condensers and circuits which are often very convenient and time-saving. I have used it preferably in a disposition similar to that indicated in Fig. 2, when the currents forming the arc are small.

I may here mention that I have also used dischargers with single or multiple air gaps, in which the discharge surfaces were rotated with great speed. No particular advantage was, however, gained by this method, except in cases where the currents from the condenser were large and the keeping cool of the surfaces was necessary, and in cases when, the discharge not being oscillating of itself, the arc as soon as established was broken by the air current, thus starting the vibration at intervals in rapid succession. I have also used mechanical interrupters in many ways. To avoid the difficulties with frictional contacts, the preferred plan adopted was to establish the arc and rotate through it at great speed a rim of mica provided with many holes, and fastened to a steel plate. It is understood, of course, that the employment of a magnet, air current, or other interrupter, produces no effect worth noticing, unless the self-induction, capacity, and resistance are so related that there are oscillations set up upon each interruption.

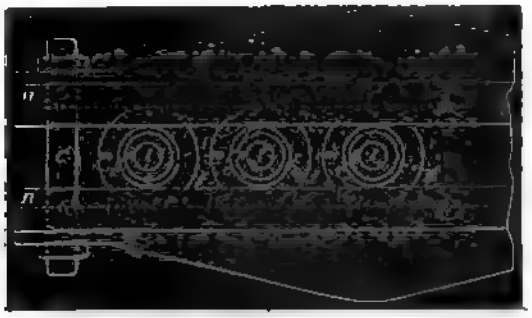


FIG. 7.—Discharger with Multiple Gaps.

I will now endeavour to show you some of the most noteworthy of these discharge phenomena. I have stretched across the room two ordinary cotton-covered wires, each about seven metres in length. They are supported on insulating cords at a distance of about 30 centimetres. I attach now to each of the terminals of the coil one of the wires, and set the coil in action. Upon turning the lights off in the room you see the wires strongly illuminated by the streams issuing abundantly from their whole surface in spite of the cotton covering, which may even be very thick. When the experiment is performed under good conditions, the light from the wires is sufficiently intense to allow distinguishing the objects in a room. To produce the best result it is, of course, necessary to adjust carefully the capacity of the jars, the arc between the knobs, and the length of the wires. My experience is that calculation of the length of the wires leads in such case to no result whatever. The experimenter will do best to take the wires at the start very long, and then adjust by cutting off first long pieces, and then smaller and smaller ones as he approaches the right length. A convenient way is to use an oil condenser of very small capacity, consisting of two small adjustable metal plates, in connection with this and similar experiments. In such case I take wires rather short, and set at the beginning the condenser plates at maximum distance. If the streams from the wires increase by approach of the plates, the length of the wires is

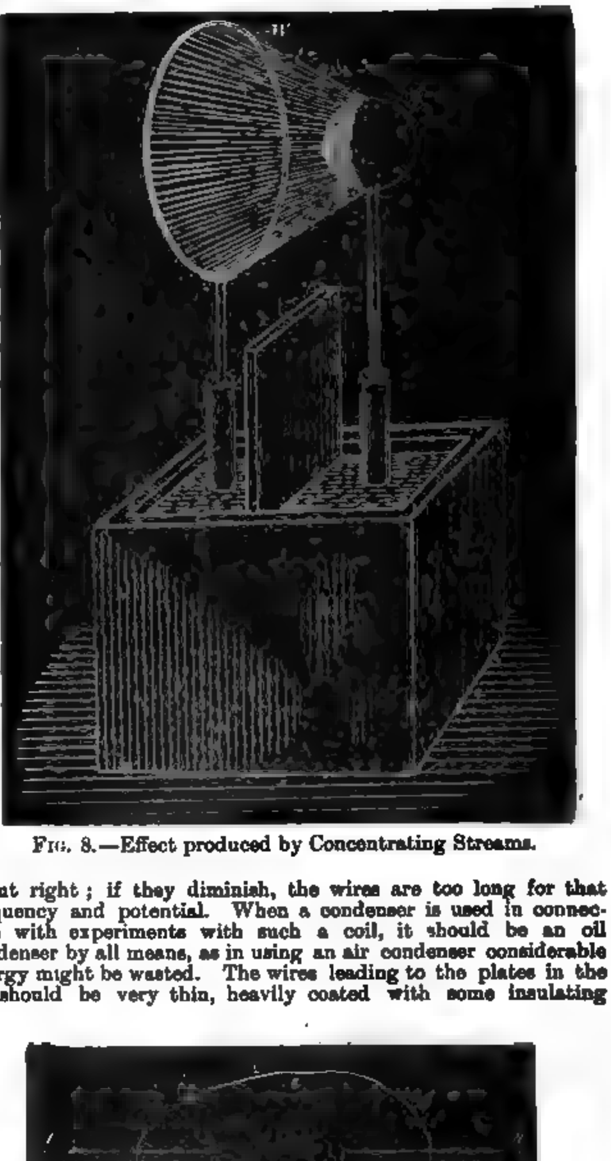


FIG. 8.—Effect produced by Concentrating Streams.

about right; if they diminish, the wires are too long for that frequency and potential. When a condenser is used in connection with experiments with such a coil, it should be an oil condenser by all means, as in using an air condenser considerable energy might be wasted. The wires leading to the plates in the oil should be very thin, heavily coated with some insulating

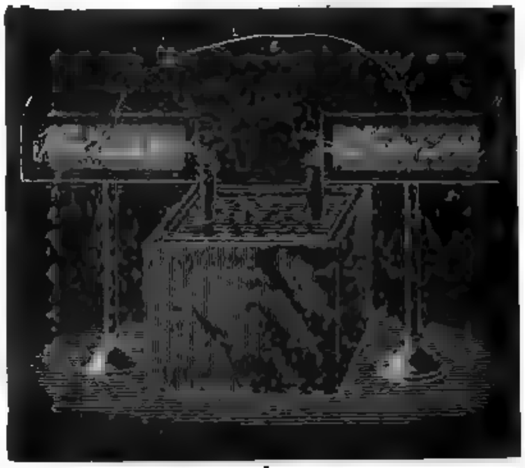


FIG. 9.—Wires Rendered Intensely Luminous.

compound, and provided with a conducting covering—this preferably extending under the surface of the oil. The conducting cover should not be too near the terminals, or ends, of the wire, as a spark would be apt to jump from the wire to it. The conducting coating is used to diminish the air losses, in virtue of its action as an electrostatic screen. As to the size of the vessel containing the oil, and the size of the plates, the experimenter gains at once an idea from a rough trial. The size of the plates in oil is, however, calculable, as the dielectric losses are very small. In the preceding experiment it is of considerable interest to know what relation the quantity of the light emitted bears to the frequency and potential of the electric impulses. My opinion is that the heat as well as light effects produced should be proportionate, under otherwise equal conditions of test, to the product of frequency and square of potential, but the experimental verification of the law, whatever it may be, would be exceedingly difficult. One thing is certain, at any rate, and that is, that in augmenting the potential and frequency we

rapidly intensify the streams; and, though it may be very sanguine, it is surely not altogether hopeless to expect that we may succeed in producing a practical illuminant on these lines. We would then be simply using burners or flames, in which there would be no chemical process, no consumption of material, but merely a transfer of energy, and which would in all probability emit more light and less heat than ordinary flames. The luminous intensity of the stream is, of course, considerably increased when they are focused upon a small surface. This may be shown by the following experiment. I attach to one of the terminals of the coil a wire, *w* (Fig. 8), bent in a circle of about 30 centimetres in diameter, and to the other terminal I fasten a small brass sphere, *s*; the surface of the wire being preferably equal to the surface of the sphere, and the centre of the latter being in a line at right angles to the plane of the wire circle and passing through its centre. When the discharge is established under proper conditions, a luminous hollow cone is formed, and in the dark one half of the brass sphere is strongly illuminated, as shown in the cut. By some artifice or other it is easy to concentrate the streams upon small surfaces and to produce very strong light effects. Two thin wires may thus be rendered intensely luminous. In order to intensify the streams the wires should be very thin and short; but as in this case their capacity would be generally too small for the coil, at least for such a one as the present, it is necessary to augment the capacity to the required value, while, at the same time, the surface of the wires remains very small. This may be done in many ways. Here, for instance, I have two plates, R R, of hard rubber, Fig. 9, upon which I have glued two very thin wires, *w w*, so as to form a name. The wires may be bare or covered with the best insulation—it is immaterial for the success of the experiment. Well, insulated wires, if anything, are preferable. On the back of each plate, indicated by the shaded portion, is a tinfoil coating, *t t*. The plates are placed in line at a sufficient distance to prevent a spark passing from one to the other wire. The two tinfoil coatings I have joined by a conductor, C, and the two wires I presently connect to the terminals of the coil. It is now easy, by varying the strength and frequency of the currents through the primary, to find a point at which the capacity of the system is best suited to the conditions, and the wires become so strongly luminous that when the light in the room is turned off, the name formed by them appears in brilliant letters. It is perhaps preferable to perform this experiment with a coil operated from an alternator of high frequency, as then, owing to the harmonic rise and fall, the streams are very uniform, though they are less abundant than when produced with such a coil as the present. This experiment, however, may be performed with low frequencies, but much less satisfactorily.

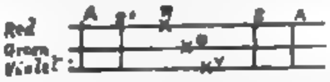
(To be continued.)

PHYSICAL SOCIETY.—April 8, 1892.

Dr. J. H. Gladstone, F.R.S., past-president, in the chair.

Mr. C. T. Mitchell was elected a member of the society.

Mr. Walter Baily, M.A., read a paper "**On the Construction of a Colour Map.**" By the term "colour map" the author meant a diagram, each point of which defines by its position some particular colour. Captain Abney had shown that all colours except the purple could be formed by adding white light to some spectrum colour, whilst all except the greens could be made to produce white by the addition of some spectrum colour. There were, therefore, two ways in which colours, other than greens and purples, could be indicated. In one of these, the ordinate of a point might represent the spectrum colour by its wave-length and the abscissa, measured to the right of a vertical spectrum line, the amount of white light to be added to the spectrum colour to produce the colour represented by the point. In the other, the abscissa of a point situated on the left of the spectrum line represents the quantity of white light produced by the addition of the spectrum colour to the colour indicated by the point. Regarding the spectrum colours as formed by mixing three primary colours (red, green, and violet) in varying proportions, three curves were drawn to the left of the spectrum line, whose abscissæ represented respectively the proportions of the three primary colours present in the corresponding spectrum colour. Horizontal distances from any point to these curves show the proportions in which the primary colours are to be mixed to produce the particular colour defined by that point. For points between the curves, the horizontal distances are not measured all in one direction, and therefore indicate abnormal or imaginary colours. The principle of the map was further illustrated by a sort of colour staff, consisting of three horizontal lines representing the three primary colour sensations (see Fig.) of such luminosities that



equal lengths of the three lines indicate white light. If points R, G, V, be taken in these lines, then a cross-line, A, will cut off lengths A R, A G, A V, whose mixture will produce a certain colour. If now A be moved parallel to itself towards the right, the colour will change by the addition of white light; moving A to the left means a subtraction of white light. When R, G, and V are properly chosen, a certain position, S, of the cross-line corresponds to a spectrum colour. The whole of the series of colours which can be obtained by adding white light to that spectrum colour can then be represented by sliding A towards the right. Positions S^1 and A^1 give colours complementary to S and A. The distinguishing features of such a series of colours are the differences R – G and G – V, and the author calls the ratio $\frac{R-G}{G-V}$ the "colour index." Passing up the spectrum from red to violet, the index, which is first large and positive, diminishes, and becomes negative between yellow and blue; it then passes through infinity and becomes positive, and decreases to zero. The subject of determining the indexes of colours resulting from the mixture in various proportions of two other colours whose indexes were known was considered, and diagrams showing the various curves exhibited. Experimental methods of determining the proportions of the primary colour sensations constituting the spectrum tints were described. A **Visitor** enquired how the author's system provided for the class of colours outside the red and violet. He also desired a definition of "white light." He himself had never been able to produce pure white by mixture of colours, for a reddish violet generally resulted. On the other hand, he found it possible to match any other colour by mixture. **Prof. Carey Foster** thought Helmholtz was the first to propound the laws which the author had attributed to Captain Abney. He wished to know how the amounts of colour sensation were supposed to be measured. White light, he considered, ought to be defined as light in which a normal eye, not fatigued, could perceive no preponderance of any colour. **Mr. Blakesley** said that if white light was a mixture, and only two unknowns were necessary, then any colour could be produced by the mixture of two other colours. **Dr. Sumpner** pointed out that white light was by no means a constant colour, but depended greatly on the source. He thought the author's map of a more absolute nature than that proposed by Maxwell. **Dr. Hoffert** enquired whether the intensities of each spectrum colour had been considered equal or otherwise taken into account, and also whether the results arrived at would be true for intensities other than those shown. **Mr. Baily**, in reply, said that Captain Abney had found the light from the crater in the positive carbon of an electric arc to be the most constant white, and in his method of experimenting errors due to variations of the source cancel. The quantity of any spectrum colour was defined by the breadth of the band used, the breadth being measured on the scale of wave lengths.

A paper on "**A Mnemonic Table for Changing from Electrostatic to Practical and C.G.S. Electromagnetic Units**" was read by **Mr. W. Gleed, M.A.** In the table which is given below the abbreviations "stat." and "mag." are used to denote the electrostatic and electromagnetic units respectively, and *v* stands for 3×10^{10}.

Units of	Capacity.	Resistance.	Potential.	Current.	Quantity.
Powers of 10 for practical and magnetic units ...	9	9	8	1	1
Small unit	Stat.	Mag.	Mag.	Stat.	Stat.
Practical unit .	Farad	Ohm	Volt	Ampere	Coulomb
Large unit	Mag.	Stat.	Stat.	Mag.	Mag.
Factor for stat. and mag.	v^2	v^2	v	v	v

To form the table, the numbers 9, 8, 1, in the middle of the second line give the value of "*g*." The end numbers are duplicated, giving 9, 9, 8, 1, 1. Below them, in the fourth line, come the names of the practical units, the initials forming the word "fovac." Remembering that the electromagnetic units of resistance and potential were too small for practical use, one places mag. above both ohm and volt. Ohm's law and definitions then show that the practical units of capacity current and quantity must be less than the electromagnetic unit, hence mag. must be written below farad, ampere, and coulomb. Since the practical units are intermediate in magnitude between stat. and mag., the vacant spaces are then filled in by stat. The *v*'s in the bottom line are added from memory. Several examples showing the use of the table are worked out in the paper accompanying the table.

A paper on "**The Law of Colour in Relation to Chemical Constitution,**" by **William Akroyd**, was read by Mr. Blakesley. The author has observed that in cases of compounds having a constant radical, R, and a variable radical, R^1, the effect of an increase in the molecular weight of R^1 is to make the colour of the compound tend towards the red end of the colour scale. Exceptions, are, however, noted.

COMPANIES' REPORTS.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY.

Directors: Sir Richard J. Meade, K.C.S.I., chairman; Major Charles Jones, vice-chairman; Edward J. Carson, Esq.; William Elmore, Esq.; George Holmes, Esq.; Sir James Mackenzie, Bart., managing director. General manager: M. Eugéne Secrétan.

First annual report and statement of accounts to be submitted to a general meeting of shareholders to be held at Winchester House on Friday, 22nd inst., at 12 noon.

Your Directors beg to submit the annexed statement of accounts for the period from the date of the Company's formation on the 6th September, 1890, up to the 31st December, 1891. These accounts deal only with capital expenditure, as no trading was carried on during the period under report. They show the outlay that has been incurred on the Company's factory at Dives, including the purchase of raw material, copper,

the preliminary experiments and arrangements for the commencement of manufacture. The enclosed circular, which gives full information of the position and prospects of the Company, explains the object of an extraordinary resolution which will be submitted to the shareholders after the adoption of the report and the accounts. The retiring Directors on this occasion, Messrs. E. J. Carson and W. Elmore, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., offer themselves for re-election.

Cr. Balance-sheet, Dec. 31, 1891.				£	s.	d.
Share capital authorised—						
100,000 shares of £2 each				200,000	0	0
Share capital issued—						
33,250 shares of £2 each allotted to the vendor company in part payment	£66,500	0	0			
66,750 shares of £2 each subscribed	133,500	0	0			
100,000	£200,000	0	0			
Less calls in arrear	484	14	0			
				199,515	6	0
Premium on 66,750 shares				33,375	0	0
Six per cent. mortgage debenture stock, redeemable in November, 1893, at 5 per cent. premium				50,000	0	0
Deposits on shares forfeited				8	0	0
Sundry creditors for outlay on works—						
In Paris, open accounts	£18,344	19	6			
In London, bills payable	9,000	0	0			
In Paris, bills payable	18,694	7	0			
				46,039	6	6
Sundry creditors in London				3,239	14	1
Note.—There are liabilities under contracts running for unfinished work in connection with the construction and equipment of the factory.						
				£332,177	6	7

Dr.				£	s.	d.
Cost of patents (including premiums on shares issued)				183,375	0	0
37½ acres of land at Dives, and cost of acquisition				6,466	3	9
Six acres of land at Bellegarde				5,270	0	0
Buildings and general works (including workmen's dwellings)				28,757	1	9
Plant, machinery, tools, etc.				64,402	18	4
Railway siding				1,390	5	11
Payments to contractors, on account of work done				3,259	10	2
Stock of copper, materials, etc.				14,832	17	3
Office furniture and fittings in Paris, and at Dives				1,085	8	6
Fittings of retail shop to supply workmen				333	4	4
Sundry debtors—In Paris	£149	4	4			
In London	223	6	0			
Cash—In Paris and at Dives	5,373	14	2			
In London	368	7	6			
				5,742	1	8
				315,287	2	0
Experimental work—						
In Paris laboratories and at Dives	2,913	18	1			
In London	103	10	0			
				3,017	8	1
Establishment charges at Dives—Salaries and allowances, stationery, fire insurance, and sundry expenses	2,326	5	6			
Establishment charges in Paris—Travelling, plans, fittings of offices, legal charges, and sundry expenses	858	8	7			
General administration charges in Paris—Fees of local committee, salaries of general manager and staff, rent, stationery, travelling, postages and telegrams, and sundry expenses	4,928	1	1			
				8,112	15	2
General administration charges in London—						
Directors' fees	2,125	0	0			
Salaries	963	14	11			
Law charges	345	4	0			
Travelling	299	11	1			
Patent renewals	169	2	0			
Rents, rates, taxes, printing and stationery, postages and telegrams, and sundry office expenses	646	16	4			
	4,549	8	4			
Less transfer fees	226	10	0			
				4,322	18	4
Debenture interest to December 31, 1891	2,057	16	2			
Less interest received from deposits, etc., in London and in Paris	681	12	2			
				1,376	4	0
Exchange difference				60	19	0
				£332,177	6	7

The following circular to shareholders, signed by Mr. Shurmur, secretary to the Company, has been issued with the Directors' report: "You were informed by your Chairman, in a letter addressed to you on the 1st day of January last, of his impressions after visiting the Company's works at Dives, near Havre, France, and that he had witnessed the commencement of the manufacture of the first tubes started in the works. Since that time great progress has been made towards completing the first portion of the works, so as to commence manufacturing on a commercial scale—namely, 300 tons per month—and the Directors are pleased to be able to announce to the shareholders that they have received official information from Mr. Secretan, the director-general, that this is accomplished, and that he is inviting all the leading copper users in France, together with the engineers of position, to visit the works after the 15th inst., and to see for themselves the remarkable quality of copper articles manufactured under the Elmore process. In the event of any shareholder desiring to inspect the works, a card of admission to enable him to do so can be had on application at the office of the Company; the Directors believe that visitors will be greatly impressed with the extent of the works, the admirable way in which they have been fitted up, and the ease and simplicity of the manufacture. At the time when the services of Mr. Secretan were secured, he impressed upon the Board, who communicated his views to the shareholders, that it would be useless to attempt to embark in the business which the French Elmore Company was formed to carry on unless the works were capable of turning out a minimum quantity of 300 tons per month, as the demand would very much exceed this quantity, and he knew that unless the Company was in a position to supply all the various descriptions of articles that would be required, a large portion of the more remunerative part of the business would be lost. His willingness to take charge of the Company's affairs in France was conditional on the establishment of works on this scale. As the shareholders are aware, at the time the Company was formed it was intended only to erect a plant capable of turning out 80 tons per month, and the capital of the Company was framed on that basis. It is obvious, therefore, that the additional capital necessary to complete the payment for the more extensive works which have been erected, and to provide the additional working capital required, amounting to £120,000, should now be raised; indeed, but for the credit enjoyed by Mr. Secretan with the contractors, that must have been done some time since; but the Directors were desirous of not coming to the shareholders until they could inform them that the factory was completed on the above scale and manufacture commenced. Accordingly, they now enclose a notice calling a meeting of shareholders to authorise an increase of the capital of the Company for the purpose above mentioned. In the circular of the Directors, dated 29th October, 1890, they communicated the fact that Mr. Secretan anticipated that the sales could easily reach 900 to 1,000 tons per month, and it will be observed in his last report, dated 1st of April, 1892, that he contemplates in a short time being overwhelmed with orders, and urges that the output should be increased from 300 tons a month to 550 tons per month, equal to 6,600 tons per year. Seeing that the consumption in France amounts to 18,000 tons a year of copper tubes, plates, rollers, wire, and similar articles, there is no doubt, looking at the increased profits, that it is good policy for the Company to adopt the suggestion to get the larger output at as early a date as possible. This will require a further sum of £120,000, making a total increased capital of £240,000. The mode by which this capital should be raised has occupied the attention of the Directors for some time past; various plans suggested themselves, and after mature consideration they have finally decided to raise it by increasing the existing £50,000 of debenture stock to £100,000, and by the issue of £200,000 of preference shares. The debenture stock will bear 6 per cent. interest, and the preference shares will be entitled to a preference dividend of 10 per cent., and, out of surplus profits, after the ordinary shares have received 15 per cent., to an extra 5 per cent., making a total of 15 per cent. Looking at the amount shown by Mr. Secretan as earnable by the entire plant intended to be erected, it will at once be realised that the preference shares to be created will be an unusually solid and exceptional investment. With a view to furnish all the information possible, the Directors called on Mr. Secretan for a report of the earning power of the plant when so completed. This report states that the profits of the factory would amount to £151,800 per annum, and it is so important and interesting that the Directors enclose a verbatim copy for the shareholders' information. The Directors have pleasure in stating that Mr. Secretan reports that his original estimate of the cost of production has already been verified by actual manufacture, and that he is of opinion that this will be materially reduced in future. As regards the prices to be realised, the estimate submitted by Mr. Secretan has been based on the scale price of ordinary articles of commerce, and mostly of the cheapest description, no credit being taken for any extra prices which will undoubtedly be realised on account of the superior qualities of our manufactures, nor for those more expensive and remunerative articles for the economical manufacture of which the Elmore process is specially adapted. The Directors are convinced, from independent enquiry, that the average price taken in this estimate will be exceeded, with a consequent augmentation of the large profits referred to. Of the new capital, the Directors propose to issue at once 60,000 preference shares of £2 each, and the remainder with the debenture stock in about six months' time, when it is anticipated that the existing works will be fully occupied. To enable the shareholders to judge of the exceptional value of the preference shares now to be created, a tabular statement is given

at the end hereof, showing the result to both classes of shares—the preference and the ordinary. It will be seen that the preference shares will be secured upon a revenue many times the amount required, whilst the existing ordinary shares will benefit by reason of there being no augmentation of them. It is intended to offer 40,000 of the preference shares now to be issued, being two-thirds of the number, exclusively to the present shareholders in the proportion of two preference shares for each five ordinary shares standing in their names on the share register on the 22nd inst., and the remaining one-third—namely 20,000 preference shares—will be offered to the general public, it being thought by the Directors desirable to have the support of many persons interested in the copper trade, who in all probability may desire to subscribe. The Directors have considered that it may be to the convenience of some shareholders to pay their instalments over a considerable period, and they have accordingly made them payable over a period of six months. The Directors, however, will reserve to those who wish to pay in advance of the due dates power to do so, in which case they will receive the guaranteed dividend referred to below from the dates of payments of such instalments. One feature of the issue will doubtless be satisfactory to the shareholders—namely, that Elmore's Foreign and Colonial Copper Depositing Company, Limited, who formed this Company, desiring to aid it in every way, have engaged to guarantee the payment for the first year of a minimum dividend of 10 per cent. upon the present issue of preference shares, so that the subscribers may be in receipt of an income from the date of the payment of the shares. That company and your Directors do not anticipate that this guarantee will be at all required, but your Directors think it right to acknowledge the liberality with which the Foreign and Colonial Company, without payment, have complied with the request made to them thus to co-operate with your Directors in giving the shareholders every advantage that the prosperous circumstances of this Company amply justify. Finally, the Directors, in announcing the arrangements made for the advantage of the shareholders, trust they will appreciate the foresight shown by your Board in having laid out the works on a scale sufficiently large to cope with the demand which has been proved to exist for the Company's manufactures, thus establishing for the Company the prestige so necessary for obtaining large and important contracts."

TABLE showing division of profits based on Mr. Secretan's estimate, with an output of 550 tons per month, upon a capital of £100,000 6 per cent. debentures, £200,000 preference shares, and £200,000 ordinary shares.

Amount of annual profit, as per Mr. Secretan's report (3,795,000f.)	£151,800
Less French officials' proportion of commission on profits and London expenses	31,560
Annual net profit	£120,240
Interest on £100,000 6 per cent. debenture stock	6,000
	£114,240
10 per cent. dividend on £200,000 preference shares	20,000
	£94,240
15 per cent. dividend on £200,000 ordinary shares	30,000
	64,240
5 per cent. extra on above preference shares making 15 per cent.	10,000
	£54,240
5 per cent. extra on above ordinary shares, making 20 per cent.	10,000
Surplus	£44,240

The surplus being available for extra dividend and reserve fund, or other purposes as may be agreed upon by the shareholders in general meeting.

Summary.

Dividend of 15 per cent. on £200,000 preference shares	30,000
Dividend of 50 per cent. on £200,000 ordinary shares	40,000
Surplus	44,240
	£114,240

The following is a translation of Mr. Secretan's report as general manager of the Company, dated April 1, 1892:

"I beg to place before you the position of your Company in France at the present time. I have the satisfaction to inform you that after long delays caused by cases of *force majeure*, by numerous studies, by multiplied experiments, and also by the necessity of adapting the different mechanisms of the Elmore process to the special requirements of French demands, the factory is entirely finished, and the final modifications brought to bear on the material first provided for are definitely realised. We have now 120 tanks actually ready to commence regular working for the manufacture of the ordinary tubes of commerce, and 144 large tanks also ready for the manufacture of sheet copper and wire. Up to the present, on account of the large programme which we set ourselves, we believe that, for various reasons and in order to avoid any misfortune, we should not accept firm orders, making an exception, however, in the case of a few of these orders, in consequence of the interest which they present for your Company. One of these orders, especially destined for the French Navy, will be delivered during the first fortnight in April. I do not hesitate to inform you that its reception will demonstrate the superiority of our productions. I am to-day informing the commercial and industrial firms in France that we have definitely commenced normal and regular manufacture, and I am soliciting orders promised me in advance by the largest firms in this country. From now to the 15th April next at latest we shall have at least 80 tanks containing 400 mandrels in full work, producing at least 100 tubes a day, of which the disposal is assured. I have much satisfaction in announcing that after our persevering efforts, all the products which we are now beginning to deliver, and shall continue to deliver each day, will answer in all respects to the programme intended to be followed of a perfect and regular manufacture. Regarding the value of our work, if you think that additional testimony to my own should be produced, you have in your hands the strong and flattering attestations of the firms Gueldry, Brimault and Tillier, Fel, and also of the old-established firm of Cail; and lastly, I propose to obtain other testimonials from the most important houses in this country. If this does not appear enough, in order to reply still more completely to all the criticisms that may arise I propose also to open the doors of the factory at Dives to all the honourable and competent experts in France, in order to show them the truth of my assertions by placing before them our manufactures just as they come from the tanks, as well as the mechanical work, the most difficult which copper can be put to. Also it would give me pleasure if you would on your side invite the most competent consumers and experts in England to see the results obtained. The most sceptical will thus be forced to give way to evidence, and this demonstration will be more convincing than words. In addition to this undeniable proof of our excellent manufactures I have the satisfaction to inform you, and the experts will be able to see it themselves, that not only will the cost price as at first announced not be surpassed, but, thanks to improvements I have been able to bring about, this price will be notably decreased. The presumed profits which I indicated to you as being possible to be realised with the projected issue of 3,000,000f. will amount to a figure very close to 1,400,000f. There is no doubt whatever that the 300 tons which we can produce with the actual organisation of the factory at Dives will be easily absorbed by the current demand, and in a short time we shall be overwhelmed with new orders. We have seen from the commencement that an increase of plant to cope with such an increase of orders would be necessary. If you are of opinion that such increase ought to be made without delay, I would propose to apply it exclusively to the manufacture of tubes of a small and of a medium size, which are required every day. Herewith I subjoin the results to be obtained with a further capital of 3,000,000f., making the new issue to 6,000,000f. We can then turn out 250 tons a month more, or a total of 3,000 tons a year, bringing an average profit of 80f. per 100 kilos., or, in other words, the new 3,000,000f. would produce a profit of 2,400,000f. (£96,000). This large profit, derived from comparatively small additional capital, is explained by the fact that the 3,000,000f. would be entirely devoted to a special manufacture, the most profitable in the copper trade, which would not, moreover, be handicapped with anything for the purchase of land, administration expenses, sidings, foundry, laboratory, and especially of patents. The reason why we have not established the Dives works exclusively for small and medium tubes is because it would have been impossible to ensure meeting all the current demands of the trade if we did not commence by also producing sheet copper, tubes, and wire. Now having to-day the means of making sheet and wire, which bring in less, while at the same time we make a certain quantity of tubes which return more profit, we are in a position to satisfy the requirements of the principal trade. Annexed are schedules showing the several profits resulting from the comparative outlay of 3,000,000f. or 6,000,000f. With an issue of 3,000,000f. our profits amount to 1,395,000f. (£56,000), and with an issue of 6,000,000f. to 3,795,000f. (£151,800). Regarding the disposal of a total production of 6,600 tons annually, there is no necessity for any fear, seeing that the production in France amounts to 18,000 tons a year, and that new sources of consumption daily arise. It is for you, gentlemen, as well as the shareholders, to determine which of these two capitals should be adopted for the new issue."

NEW COMPANIES REGISTERED.

Corlett Electrical Engineering Company, Limited.—Registered by C. Doubble, 14, Serjeant's-inn, E.C., with a capital of £10,000 in £10 shares. Object: to carry into effect an agreement made April 2 between G. S. Corlett of the one part and J. C. Kenyon, on behalf of this Company, of the other part, for the acquisition of the undertaking of an electrical engineer, now carried on by G. S. Corlett, at Wigan and Bolton, Lancashire, and to develop and extend the same in all its branches. There shall not be less than three nor more than seven Directors; the first to be elected by the signatories to the memorandum of association. Qualification, £300. Remuneration to be determined by the Company in general meeting.

Electric Cycle Syndicate, Limited.—Registered by Goldring, Mitchell, and Philips, 20, Abchurch-lane, with a capital of £3,000 in £1 shares. Object: to carry on business as electrical and mechanical engineers in all its branches. Registered without articles of association.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended April 8 were £3,052, and those for April 15, £2,746.

West India and Panama Telegraph Company.—The estimated traffic receipts for the half-month ended April 15 are £2,673, as compared with £3,661 in the corresponding period of 1891. The December receipts, estimated at £4,878, realised £4,914.

City and South London Railway.—The receipts for the week ending 17th April were £734, against £816 for the same period of last year, or a decrease of £82. The total receipts to date from January 1, 1892, show an increase of £1,088, as compared with last year.

Removal.—Mr. Robert G. Ivey informs us that he has removed from 22A, Chatham-place, Hackney, and has taken larger premises with steam power at 7, Portpool-lane, E.C., where he has facilities for carrying out every description of electrical manufacturers' work. Mr. Ivey is making a speciality of repairing dynamos.

In Liquidation.—Mr. F. G. Painter (of the firm of Tribe, Clarke, Painter, and Co.), the official liquidator of the Electrical Automatic Delivery Box Company, Limited, will, with the sanction of Mr. Justice Kekewich, pay a first and final dividend of 1s. 8½d. per share on and after the 19th inst., at his offices, 19, Coleman-street, E.C. The creditors have been previously paid 20s. in the pound.

Dublin.—Tenders are being invited for a complete installation of telephones and electric bells at the new Hotel Metropole, Sackville-street, Dublin, for Mr. R. Mitchell. Plans and specifications may be had from Mr. W. Leake, electrical engineer, 30, Victoria-buildings, Manchester, for which a charge of £1. 1s. will be made, the same to be remitted on receipt of a bona fide tender. Tenders to be enclosed in a sealed envelope, endorsed "Tender for Telephones," and sent in by 27th inst.

Great Northern Telegraph Company.—For the year 1891 the accounts of the Company show, including £48,216 brought down, receipts £359,646, and expenses £65,448. The interest on debentures and amortisation absorbed £21,250, and the interim dividend of 5 per cent. paid on 150,000 shares and the extra dividend of 7s. 2d. required, together £129,166. In addition £83,333 was placed to the reserve and renewal fund, £2,777 added to the pension fund of the staff, £1,500 apportioned as remuneration to Directors, and £56,169 carried forward.

The Bell Telephone Company, at its last annual meeting in Boston, increased its capitalisation from 15,000,000dols. to 17,500,000dols. The instruments in use amount to 512,407, an increase over 1890 of 28,617; exchanges 788, increase 14; total miles of wire 266,456, increase 26,044. The estimated number of telephone connections daily in the United States made up from actual count in most of the exchanges is 1,584,712, or a total in the year exceeding 500,000,000. The total revenue reported by all companies was 1,638,653dols. The "long-line" company—the American Telephone and Telegraph Company—intends during the course of the current year, to fill the gap between Cleveland, O., and Hammond, Ill., which last-named place is already connected with Chicago, thus giving through Boston, New York, and Chicago.

PROVISIONAL PATENTS, 1892.

April 11.

6888. **An improved conduit system for electric conductors.** Wilfred L. Spence, The Elms, Seymour-grove, Manchester.

6911. **Improvements in change-over mechanism for electric arc lamps.** William James Davy, 30, Cornwall-road, Stroud Green, London.

6949. **Improvements in and apparatus for the electrolysis of solutions of salts or compounds of the alkalies, more especially intended for the manufacture or production of alkalies and chlorine and for bleaching.** Julius Marx, 47, Lincoln's-inn-fields, London.

6954. **Improved means of producing motive power and electricity.** Richard J. Crowley and William Walker, 22, Coltart-road, Liverpool.

6961. **Improvements in automatic switches for electrical apparatus.** Albrecht Heil, 4, South-street, Finsbury, London. (Complete specification.)

April 12.

6989. **Improvements relating to conduits, applicable for combined use as casings for electrical conductors and for gas supply, or for either use separately.** John Alexander McMullen, 124, Chancery-lane, London.

7003. **Improvements in coal-cutting machines with special reference to electrical motive power.** Robert John Charleton and Henry Walker, 46, Lincoln's-inn-fields, London.

7004. **Improvements in electrical cooking apparatus.** Andrew Wallace, 46, Lincoln's-inn-fields, London.

7008. **Improvements in electric light fittings.** William Arthur Heyes, 21, Finsbury-pavement, London.

7009. **An improved telephone transmitter.** Henry Skipper and Henry James Pierce, 97, Newgate-street, London.

7016. **Improvements in electric fittings.** James McFarlane and *William Burgess* Edgar, 154, St. Vincent-street, Glasgow.

7029. **Improvements in electric cables.** George Gatton Melhuish Hardingham, 191, Fleet-street, London. (The firm of Felten and Guilleaume, Germany.)

7037. **An improvement in electric arc lamps.** Reginald Belfield, 28, Southampton-buildings, Chancery-lane, London.

7004. **Improvements in dynamometers.** Edgar James Wood, 6, Bream's-buildings, Chancery-lane, London. (Complete specification.)

7081. **Improvements in telephone and electric signalling circuits between trains and signal-boxes.** John Dampier Hickman, 22, Southampton-buildings, Chancery-lane, London.

April 13.

7088. **An improved dry battery.** Arthur William Wetherelt, 97, Newgate-street, London.

7095. **Improvements in electric arc lamps.** James Sugden and Wallace James Lambert Sandy, 99, Wyndham-road, Camberwell, London.

7126. **Improvements in electrical distribution.** Arthur Wright, 26, Park-crescent, Brighton.

7142. **An improved method of renewing incandescent electric lamps.** Ernst August Kruger, 191, Fleet-street, London.

7144. **Improvements in secondary batteries.** George Hawkins Cutting, 77, Chancery-lane, London.

April 14.

7170. **An improvement in primary batteries.** Thomas Edwin Weatherall, 42, Annandale-road, East Greenwich.

7172. **Electrical surgical instruments.** Stephen Rowe Bradley, 70, Chancery-lane, London. (Complete specification.)

7206. **Improvements in or connected with connections or couplings for electric and other cables and ropes.** Arthur Annesley Voysey, 15, Water-street, Liverpool.

7220. **An improved primary battery.** Fred Beddow Stone, Eardley Villa, Belvedere, Kent.

7226. **Improvements in or relating to the electric treatment of metal or other bodies.** Carl Hubert Auguste Hoho and Eugene Auguste Clement Lagrange, 323, High Holborn, London.

7235. **Improvements in coal-cutting machines with special reference to the application of electrical motive power.** Robert John Charleton and Henry Walker, 46, Lincoln's-inn-fields, London.

7237. **Improvements in commutators for electrical machines.** Buchanan Stewart Paterson and John Brokenshire Furneaux, 46, Lincoln's-inn-fields, London.

7252. **Improvements in electrical distributing apparatus.** Rookes Evelyn Bell Crompton and William Ashcombe Chamen, 55, Chancery-lane, London.

7253. **Improvements in generating electricity and producing air in a luminous state, and in apparatus therefor.** Terrence Duffy, 45, Southampton-buildings, Chancery-lane, London. (Complete specification).

7264. **Improvements in electric arc lamps.** Haydn Theis Harrison, 46, Lincoln's-inn-fields, London.

April 16.

7275. **Improvements in electric meters.** Herbert Woodville Miller, 2, York-mansions, Earl's Court, London.

SPECIFICATIONS PUBLISHED.

1891.

3570. **Electro-therapeutic apparatus.** George.
8031. **Electric heating, etc.** Howard.
8126. **Dynamo-electric machines.** Philpott.
9079. **Electrolytic extraction of metals, etc.** Hoepfner.
9423. **Electric incandescent lamps.** Grenfell.
16270. **Electric accumulators.** Thompson. (Correns.)
17655. **Heating metals by electricity.** Burton and others.

1892.

177. **Electric drop lights.** Painter.
2330. **Electric switches.** Gimingham.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2⅜
India Rubber, Gutta Percha & Telegraph Co.	10	20¼
House-to-House	5	5⅜
Metropolitan Electric Supply	—	8⅜
London Electric Supply	5	1
Swan United	3½	4¼
St. James'	—	8⅝
National Telephone	5	4½
Electric Construction	10	6¼
Westminster Electric	—	6⅞
Liverpool Electric Supply	5	5⅛
	3	3

NOTES.

Milan.—An international electrical exhibition is to be held at Milan in 1893.

Keighley.—The increase of consumers using the electric light is exercising the Gas Committee of Keighley.

Bray.—The electric installation at Bray, Ireland, is driven by a pair of 25in. Victor turbines of the horizontal type.

Sherborne.—There being no tender for the electric indicator required by the Sherborne Local Board, the matter has been adjourned.

Electric Light Cables.—Mr. Stuart Russell's work upon electric light cables and the distribution of electricity is about to be translated into French and Spanish.

Crystal Palace Jury.—The name of Mr. Albion T. Snell has been added to the jury of Section 3—dynamos and motors—for the Crystal Palace Exhibition awards.

Bromley.—An Electric Lighting Committee of the Bromley Local Board has been appointed, consisting of Messrs. Thomas Davis, T. C. McIntyre, G. H. Payne, and H. Selby.

Royal Institution.—A course of experimental lectures on "The Chemistry of Gases," is being given by Prof. Dewar, F.R.S., on Thursdays, at 3 o'clock, at the Royal Institution.

Chicago Exhibition. — The Royal Commission (Society of Arts, Adelphi, London) announce that no charge will be made for space in the British Section of the above exhibition.

Willenhall.—A notice is to be moved by Mr. Trubshaw that the Willenhall Board consider the question of buying up the gas works, and taking the illumination of the town into their own hands.

Concert.—A very successful smoking concert was given on Friday at The Champion Hotel, Aldersgate-street, by the instrument inspectors of No. 1 division of the National Telephone Company.

Technical Instruction.—A post is open at St. Helens as organiser of technical education to the Town Council at £180 a year; preference given to those able to lecture on technical subjects.

Magnetism.—A prize is offered by the Industrial Association of Berlin of a gold medal, value £150, to the author of the best work upon the magnetism of iron, to be sent in before 15th November, 1893.

Turkish Telegraphs.—Tenders are being obtained for the supply of iron telegraph posts and insulators for the Turkish Government. The specification can be seen in the Musée Commercial, rue des Augustins, Brussels.

Bexhill.—The Viscount Canteluре has entrusted the lighting of his new house at Bexhill to Messrs. Drake and Gorham, who are now engaged in putting down an installation for lighting the house, outlying buildings, and grounds.

Belgian Electric Railways.—The Belgian Minister of Public Works is investigating the working of electric tramways in Europe, with a view, it is stated, of the probable adoption of electric traction on the Belgian State railways.

Paris.—The electric lighting company for the Secteur des Champs-Elysées at Paris has received authorisation to place armoured main cables for high-tension alternate currents direct in the ground, and to place transformers in the houses of customers.

Society of Arts.—Considerable interest is likely to be shown in the paper to be read on May 4, at 8 p.m., before the Society of Arts, on "The Bradford Corporation Electricity Supply," by Mr. Jas. N. Shoolbred. Mr. W. H. Preece, F.R.S., will preside.

Recovering Gold from the Sea.—We see it is proposed to attempt in likely places to recover the dissolved gold from the sea. The low E.M.F. required is supposed to promise that gold might even be recovered at less cost than by mining. We doubt it.

Grounded Mains.—A considerable discussion is being carried on in New York with reference to the advisability of grounding the third, or neutral, wire in the three-wire system. Prof. Henry Morton gives an emphatic opinion that this practice increases the fire risk.

Sheffield.—A joint meeting of the Chesterfield and Midland Counties Institute of Engineers and the Midland Institute of Mining, Civil, and Mechanical Engineers will be held at Sheffield on the 3rd of May, when several papers will be read and visits paid to various collieries.

Bideford.—At the last meeting of the Local Board, one of the members, Mr. Restarick, upon the acceptance of the gas company's tender for lighting, enquired how they stood with respect to electric lighting. He pointed out that they were making improvements in the town, and he thought it desirable that the electric light should be introduced.

Sale of Plant.—As will be seen from their advertisement, Messrs. Wheatley Kirk, Price, and Goulty have an extensive sale of electrical plant at 39, Queen-street, E.C., on May 17th and 18th. The sale comprises dynamos, engines, boilers, arc lamps, fuses, instruments, and so forth, and most of the principal items are stated to be new, or practically new.

Electric Street Railways.—A Boston news bureau reports that out of the 16 cities of over 200,000 population in the United States, 14, or over 87 per cent., are using the electric railway system or equipping roads with the system; and out of 42 cities with population ranging from 200,000 to 50,000, all but one are using the electric railway system.

Southport.—At a special meeting of the Southport Town Council on Tuesday, the Council accepted an offer for the transfer of three acres, one rood, and 18 perches of land adjoining the gas works. It was explained that about three acres of the land would be utilised for electric lighting. The question of a destructor on the remainder of the land was raised, but not discussed.

Cardiff.—Messrs. Tucker have recently erected what is described as one of the finest flour-mills in the kingdom. It is nearly 100ft. high, and occupies an area of over 30,000 superficial feet, of which nearly 8,000 will be devoted to milling. The machinery is driven by compound engines of 800 h.p., and the whole will be lighted throughout by electricity, by plant supplied by Mr. Wilson Hartnell.

The Engineering Exchange.—We are informed by the secretary that the Engineering Exchange opens on Monday next, May 2, at 12 o'clock. The opening meeting will be in the exchange-room of the "Jerusalem," Limited, Billiter House, Billiter-street, E.C., where the committee have secured preliminary accommodation. All parties interested in engineering are invited to attend at the opening.

Fire Alarms for Chelmsford.—Tenders are required for providing, erecting, and maintaining a system of electric fire alarms and telephonic communication for the Chelmsford Town Council. A map showing positions and a specification can be seen at the office of Mr. G. H. Sasse, borough surveyor, 14, Museum-terrace, Chelmsford, on and after

25th inst. Tenders to be sent to Mr. T. Dixon, town clerk, Chelmsford, by noon on May 4.

Moscow. — MM. Koultchitohi and Stabrowski are founding a Franco-Russian electrical manufacturing company at Moscow with a capital of four million francs. It is intended to establish a large works containing plant for the manufacture of all kinds of electrical apparatus, telephones, dynamos, motors, and electric railway material. M. Stanilas Esmon, 65, Rue du Moulin-Vert, Paris, is the agent of this new Russian company.

Primary Batteries.—It has been thought that the requirements of the primary battery competition established by the journal *Elettricita* of Milan, that the price per kilowatt-hour should not exceed one franc, will stop some inventors from sending in their apparatus. The proposers state that the battery which comes nearest to the requirements will be selected, and that propositions will be made for taking out patents and putting the apparatus in the market.

Electric Launches on the Thames.—Mr. W. S. Sargeant, electric and steam launch builder, of Strand-on-the-Green, Chiswick, and Eel Pie Island, Twickenham, has received an order for an electric launch from W. T. Crawshay, Esq., of Caversham Park, Reading, Berks. The boat will be running on the Thames this season. The accumulators used will be the Electrical Power Storage Company's latest boat type, which have proved very efficient for the electric boat service.

Isle of Man.—The international exhibition to be held at Douglas from July to September this year is to be lighted throughout by electricity, and with commendable foresight the promoters, having in view the probability that the exhibition will be the first of a series to be held in the same buildings, have determined to make the electric light installation a permanency. The contract is in the hands of the Brush Electrical Engineering Company, who have undertaken to have everything in readiness by July 4.

Popular Electricity.—We are in receipt of "A Guide to Electric Lighting: for the Use of Householders and Amateurs," by S. R. Bottone, published by Whittaker and Co., price 1s. It contains a considerable number of illustrations, many of them of modern apparatus. The title explains the nature of the book, which gives concise description of apparatus without enlargements on the theoretical aspect of the science. A chapter is given on cost of lighting and another on the cost of driving a motor.

Celluloid Battery Plates.—The Winkler secondary battery, as described in the *Electrical World* for April 9th, consists of V-shaped troughs of celluloid, having a metallic conductor lying along the bottom, the trough being filled in with peroxide paste. It is claimed that the conductor can be made of sufficient carrying capacity to dispense with lead frames altogether. The electrolyte may be liquid, or semi-solid for portable uses. The weight of cell, it is stated, is reduced 40 or 50 per cent. of that of lead plate accumulators.

Dundee.—At a meeting of the Works Committee of the Dundee Gas Commission on Monday, ex-Provost Brownlee reported that Prof. Kennedy had been in Dundee and had inspected the proposed site for the electric lighting station, and also the proposed area to be supplied with the new illuminant. No report had yet been received from him, but it was expected every day. It was agreed to call a special meeting of the Commission as soon as the report comes to hand, the desire being that, as time now presses, the matter should be arranged as early as possible.

Dublin.—Tenders are invited for the supply of wires, fittings, and sundries, and the erection of same, for the electric lighting of some of the civic buildings for the Lord Mayor and Corporation of Dublin. Specifications may be obtained at the offices of the borough surveyor, Mr. S. Harty, City Hall, Dublin, and at the offices of the electrical engineer, Mr. E. Manville, 39, Victoria-street, Westminster, on payment of one guinea, which will be returned on receipt of a *bonâ fide* tender. Tenders must be lodged with Mr. John Beveridge, town clerk, City Hall, Dublin, by 5 p.m. on 10th May.

Italian Electric Railway.—A project for an electric railway has been approved of by the Provincial Technical Office, says the *Daily News* Naples correspondent, which, if carried out, will give a much more easy mode of visiting the beautiful Sorrento peninsula than exists at present. The railway is to run from Castellamare through Vico, Serano, Meta, Carotto, St. Aguello, and Sorrento to Massa, at the point of the peninsula. The projectors declare that if their plan be carried out they will offer to the towns above named great advantages for their illumination by electricity.

Aurora Borealis.—Mr. J. L. Moore, of Chorlton-cum-Hardy, writing to the *Manchester Guardian*, says there was a remarkably fine display of aurora borealis on Monday, visible between 9.30 and 10. A broad luminous arch extended from the north-west to the north-east, and from it many shafts of light radiated upwards, shining sometimes brightly and sometimes softly, several of them assuming at intervals a faint crimson glow. The sky was brilliantly starlit, Venus in particular shining resplendent in the west. It would be interesting to hear if any magnetic disturbance was contemporaneously observed.

Liverpool.—Notice is given that the Board of Trade have issued a provisional order for electric lighting for inclusion in a confirmation Bill about to be introduced into Parliament to the Liverpool Electric Supply Company, Limited, repealing the Liverpool Order of 1889, extending the area of supply, and amending the provisions of the 1891 order. Copies of the 1892 order are on view at the town clerk's office, Liverpool, and printed copies, price 1s. each, are obtainable at the company's offices, 15, Highfield-street, Liverpool, and in London at Messrs. Field and Roscoe, 36, Lincoln's-inn-fields, W.C.

South Africa.—Projects for the transmission of water power by electricity are being brought forward in South Africa. There is a fall of water near Table Mountain, some three miles from Cape Town, which it is proposed to utilise. The Hardeck Falls, 12 miles from Maritzburg, Natal, are also to be used. We notice also that the Johannesburg Gas and Electric Company are inviting more capital in debentures, though this is not for transmission of power, but for lighting the town. The town of Pretoria had had a very complete specification prepared, but nothing definite was, we believe, done in actual installation of plant.

Bell Telephone Company, Antwerp.—In reference to our notice of the Western Electric Company's Antwerp factory, Mr. Kingsbury writes that this factory, as well as the other European factories of the company, has been since its foundation under the charge of Mr. F. R. Welles, under whose care the company's business over here has assumed its present position. His absence from the factory at the time of our visit was occasioned by the fact that his increasing labours for many years past have necessitated a brief respite from the more immediate management of the Antwerp factory, though still directing the company's European business generally.

Dublin.—At a special meeting of the Dublin Corporation on Wednesday, it was resolved, on the report of the Electric Lighting Committee, that an amount of about £1,000 should be authorised for expenditure on distribut

ing mains for private lighting. The committee do not propose to lay mains or erect posts for arc lighting at present. The Corporation received sanction to borrow £37,000, and on February 11, 1891, had authorised a contract with the Electrical Engineering Company of Ireland for £29,714. The item for mains was part of the balance. Mr. J. L. Robinson said the demand for electric lighting far exceeded the most sanguine expectations of the committee.

Telephoning in the Army.—Colonel Keyser, the inspector of signalling at Aldershot, states that the officers feel an objection to the use of telephones on the field from the absence of record, as anyone might go and shout a message. The continental armies are giving attention to the use of the telephone; it has not been yet much adopted by us on outpost duties, though the service possesses a cable, weighing only 70lb. per mile, that will stand a strain of 500lb., and may be passed over by artillery without damage. In the vibrating sounder, moreover, we possess an instrument which, in combination with a telephone, will transmit signals through bare wires laid on the ground, or even through water.

Electric Light and Traction in Sweden.—The first electric locomotive made in Sweden has been turned out by Messrs. Edwin Andren and Co., of Gothenburg. It is worked by accumulators, and is of 10 h.p. It is designed to transmit electrical energy for lighting and industrial purposes to the town of Ostersund from a waterfall 10 miles distant. The necessary steps towards carrying out the scheme have already been taken, making the town the first in Sweden supplied with electricity in this manner. The Corporation of the city of Linköping has decided upon establishing an electric central station for lighting at a cost of £12,000. It will be worked from a neighbouring waterfall, producing a force of 215 h.p.

Smoke and Profits.—It is not generally known that the consumption of coal is subject to very severe supervision in Paris, in order to prevent the production of fog and smoke. The importation of coal is retarded by a considerable impost, and that of wood and coke is encouraged It is for this reason that soft coal is little consumed in the gay city, to its great benefit in aerial perspective. The fact militates against profits in certain industries, and amongst others the central electric station of the municipality, at the Halles Centrales, has recently felt obliged to use coke instead of coal on account of the stringent regulations as to smoke consumption, and has applied for a grant of 40,000f. to defray the extra cost of this class of fuel.

Moral Electricity.—John Wesley has been credited in certain quarters with professing moral cures by means of electricity. While this was far from what the worthy doctor meant, there is another doctor, Dr. Whitehouse, who advocates the gentle stimulus of the Ruhmkorff coil as a cure for unruly boys in the Newark City Home. A boy named Rafferty tried to stab one of his companions, and in darkened room, with bared neck, he was plied with stinging electrodes from the buzzing apparatus. The boy probably thought he was going to be electrocuted, and spread the report that he had been stung by red-hot needles and awfully tortured. The method has proved effective, and no second application has ever been required. The authorities consider it an entire success for reducing vicious tendencies.

City Guilds Institute.—The annual meeting of the governors of the City and Guilds of London Institute was held on Wednesday, Lord Selborne in the chair. The report showed that the expenditure at the Central Institution was £11,489, the students' fees amounting to £4,086, the net cost being £7,403. The Finsbury College expenditure amounted to £8,786, students' fees bringing in £3,032, the cost being thus £5,754. The net cost of technological examinations was £5,620. The expected income for the present year was £31,870. Lord Selborne, in the course of an address, reported very favourably upon the work accomplished in all departments. The work carried out at the Central Institution during the past year compared most favourably with that attained by any science institution in the country.

Derry.—A meeting of the Lighting Committee of the Derry Corporation was held on the 21st inst. Councillor Magee, as chairman of the Lighting Committee, presided. The business of the meeting was to appoint an electrical engineer to visit and inspect the city, and confer with the Corporation and advise as to the best system to adopt for the public and private lighting of Londonderry by electricity under the powers conferred by the provisional order, and to prepare a full report and recommendation in writing thereon. The committee, in response to advertisements in the leading electrical journals, received applications from 32 gentlemen, six of whose names at a previous meeting had been placed on a selected list to be considered at this meeting. After fully considering and discussing the qualifications of the several candidates, the choice fell upon Mr. Henry W. Blake, of Manchester, who was then formally appointed.

Bath.—Some of the councillors of Bath have been expressing disapproval of the amount of light given out by the lamps. Mr. Gatehouse, the surveyor, as will be remembered, has brought up a full report, and Mr. Norris, in commenting upon the report at the meeting last week, said the real cause of the difficulty had been the globes. They had produced a brilliant light, and then obstructed it in a most effectual manner by the globes. Now they had already grappled with that obstruction to the extent of 30 per cent., and he thought they had obtained a good instalment of the improvement they all desired. Mr. Gatehouse was fully abreast of his duties, and in getting rid of a dirty globe he had done as much good as by bringing in a lot of scientific apparatus. Some discussion ensued as to the matter of improved globes, which Mr. Sturges mentioned were used in Milsom-street, and subsequently a resolution was passed requesting the electric lighting company to at once replace the imperfect globes by those of an improved description. The report was adopted.

City Lighting.—Colonel Haywood, in his report to the Commissioners of Sewers on works executed during 1891, gives the details of the progress of the contracts and works for the electric lighting of the City of London. In 1890, the contracts were assigned to the Brush and Laing-Wharton Companies, and in January, 1891, the Commissioners gave their sanction to the placing of a main junction-box in Walbrook, and on 3rd February the work was inaugurated by the Lord Mayor with ceremony. At the end of 1891, the Brush Company had established a central station at Meredith's Wharf, and laid their mains in Queen Victoria and Cannon streets, St. Paul's-churchyard, Queen-street, Walbrook, and Mansion House-place. They had also fixed 25 lamp columns in Queen Victoria-street, which were experimentally lighted on and after 17th June, and most of the gas was finally discontinued on 21st September. At the end of 1891 the Laing, Wharton, and Down Syndicate had laid mains in Lower Thames-street, Arthur-street East, King William-street, Cornhill, Gracechurch-street, and Lombard-street, and had established a central station at Wool-quay, Lower Thames-street. They had erected 25 posts, and temporarily

lighted King William and Gracechurch streets and part of Cornhill. On January 6 this year they permanently lighted these streets, and the largest portion of the gas has been discontinued. On August 21 the contracts were transferred to the City of London Electric Lighting Company. The company pushed the work on vigorously during the month of December and the present year, and has been actively engaged in carrying forward the laying of street mains.

Coast Communication.—Every electrical engineer will feel gratified this week to hear that Sir J. Ferguson, the Postmaster-General, in reply to the resolution of Sir Edward Birkbeck in the House of Commons on Wednesday, made the definite announcement that the Government were prepared to take in hand the improvement of our coast communications. Sir E. Birkbeck's resolution was to the effect that it was desirable that all coastguard stations on the coast and signal stations should be telephonically and telegraphically connected, and where such stations do not exist the post offices should be connected, and that a Royal Commission be appointed to enquire into the desirability of connecting certain light-vessels and lighthouses by cable with the mainland. In this matter he said we were far behind Denmark, the United States, and Holland. Sir J. Ferguson stated that the Government recognised the necessity for extension of the telegraph communication on the coast, and had framed an estimate of the working cost necessary to connect telephonically the coastguard stations from the Isle of Wight to Lynmouth in North Devon. Exact calculations showed that the cost would be something over £16,000. The matter had now got beyond the stage of contemplation, and the engineers of the Post Office were taking active steps to give effect to the scheme. A rough estimate had also been made of the cost of establishing communication between all our lighthouses and lightships and the shore, and it was calculated that nearly £300,000 would be required for the purpose. It was the intention of the Government to appoint a Royal Commission to investigate, and they gladly assented to the motion of his hon. friend. The resolution was agreed to.

Melbourne.—The specification for the Melbourne central electric station has called forth an animated expression of opinion from Messrs. Siemens and Halske, of Berlin, who had been invited by their agents in Melbourne to tender for the supply of the electrical machinery required in the municipal scheme. Specifications were sent to the firm by their Melbourne agents, and papers from Australia give the following as an extract from their reply: "We regret to learn from these conditions that it is intended to use high-tension continuous current to run the arc and incandescent lamps in series. This system is based entirely on American principles, especially on constructions of the Thomson-Houston International Company. After full consideration, and on the strength of our experience, we are of opinion that our participation in the competition would be quite unsuccessful. To fulfil the conditions of the specifications we would have to make special constructions for this project, and it seems to us certain that we should be defeated on account of the prices of the inferior manufactures of the competitors. We would ask you to use all your influence to cause issues regarding the electric lighting of towns to be made in the future according to the approved European mode, where the firms participating in the competition get the details for the distribution and consumption of light and power, it being left to the submitters to propose a system which according to their experiences is the most correct and best. . . . It would be a pity if the Australian towns would subject themselves to American influence. In consequence of our great experience, we are able to propose and to execute the best system for electrical central stations of any size; we cannot, however, consent to such a plan as that proposed by the city of Melbourne."

Carbon Transmitter without Electrodes.—We have been asked for particulars of Mr. Charles Cuttriss's telephone transmitter without electrodes with spiral carbon springs. This was described in the New York *Electrical Engineer* of December 16, 1891. Experimenting to obtain data on the resistance of carbon contacts under different pressures and with different currents, Mr. Cuttriss found that in one experiment a steady movement of the galvanometer showed an increase in resistance, while the opposite effect was anticipated. Examining the carbon contacts with a strong magnifying-glass, it was found there was at first good contact between the carbons, but as they expanded under the heat the surface became raised until the contact became so small that it became incandescent for an instant, when the points fell together again and the action was repeated in cycles of 30 seconds. It occurred to him to construct carbons which should have a tendency to spring open and yet preserve continuity of contact. After some trouble he constructed carbon helices for this purpose. Some of these have a resistance in their natural condition of 10 ohms, but when fully distended the resistance is upwards of 500 ohms, and a movement of $\frac{1}{100}$th of an inch tending to open the convolutions, makes a variation of 100 ohms or more. These did not spark until the whole helix was heated to 300deg. or 400deg. F. The absence of sparking under heavy battery seemed to be a valuable feature for a telephone transmitter, as there should be an absence of ear-breaking "kicks." He devised an arrangement in which the helical carbon spring is permanently cemented to the diaphragm, and presses against the end of an adjusting screw, by which its tension can be regulated. The instrument was a success, not only was speech transmitted loudly, but the enunciation was so remarkably clear that he was led to seek some particular reason for this. He attributes it to the extreme lightness of the helix (generally less than one grain), to the elimination of electrodes or contacts, and the fact that each particle of the carbon, being in tension, prevents jamming of the surfaces.

Paris Electric Railway.—The Conseil Municipal of Paris has recently approved the project for a tubular electric railway from the centre of the city to the heights of Montmartre. The project is due to M. Berlier, engineer. It comprises a gigantic tube of cast iron five metres diameter (16½ft.), the thickness of metal being 2½ centimetres (1in.). Within this tube, brilliantly lighted by electricity, a series of trains, each containing 50 passengers, at intervals of a few minutes, will be run at a speed of 20 kilometres (12½ miles) an hour. The system is admitted greatly superior to that of the cable tramway to Belleville, the working of which is very defective, and blocks instead of clearing the road. The central terminus of the new electric line would be beneath the block of buildings at the intersection of Rues Faubourg-Montmatre, Mauberge, and Lamartine. From there the line would run in a straight line up the Rue Muton to the Butte Montmartre, and descend with a slight bend to the Place Marcadet. This was originally to be the further terminus, but to serve the populous district of Clignancourt M. Berlier has carried the proposed terminus 500 metres further, to the intersection of Rues Champronnet, Duhesme, and Boulevard Ornons. Six stations will be installed—viz., at Carrefour de Chateaudun, Boulevard Roche Chouart, Place

Saint-Pierre, Butte Montmartre, Place Marcadet, and Carrefour Championnet. The last three will be open to the air; that at Saint-Pierre will be 20 metres below surface, served by hydraulic lifts. The method of traction proposed is peculiar, consisting of a combination of cable and electric traction. The cable, instead of being itself in motion, will be fixed, and the carriages will draw themselves along the cable. An electric motor placed on each car will drive a drum around which the hauling cable will pass, and will thus be capable of regulating their speed at will of the driver. The tube will contain two narrow railway lines for up and down traffic; the space between the rails will be so arranged as to be of normal gauge (4ft. 8½in.), so that at night the waggons of the ordinary lines can penetrate to the Central Markets by means of a connection with the present Ceincture and the future Metropolitaine line. The time taken from terminus to terminus, including the slowing to seven kilometres an hour up the hill, and all stoppages, will be eight to nine minutes only. The charge is fixed at 20c. (2d.), the tickets including a return journey at any hour of the same day.

French Physical Society.—The opening evening of the exhibition of the Société Française de Physique was a great success, everyone being pleased to witness a repetition of Tesla's brilliant experiments by Dr. D'Arsonval, who has been able to simplify the apparatus required for experimental purposes A large Ruhmkorff coil, supplied with current from a set of accumulators, had its secondary circuit connected to a condenser, the terminals of which were fitted with knobs. The condenser discharged itself, and this current was sent into a second Ruhmkorff placed in oil. The secondary of this was terminated by two knobs, between which the sparks of high frequency passed. The requisite frequency was obtained by the oscillation of the charge in the condenser circuit. All the experiments of Tesla were repeated with this apparatus — illumination of tubes at a distance, lighting lamps with one wire, and harmlessness of the current to the body. Prof. Elihu Thomson's magnetic rotation experiments were reproduced, and some toy three-phase current apparatus were exhibited. The Renard primary battery, used by the Government for their flying machine, was shown lighting lamps and driving motors. A simple controller for incandescent lighting consumption, by Maxime Laille, attracted attention by its simplicity and the surety of its action. MM. Richard Frères had a large selection of their registering instruments. A new battery by Flavian Poudroux attracted attention, using zinc, carbon, chlorhydrate of ammonia, and bichromate of potash, using both surfaces of amalgamated zinc, and giving four volts, 40 amperes; interior resistance, 0·1 ohm. M. Branly reproduced his interesting experiments on the behaviour of insulators. A battery, galvanometer, and a cylinder of the insulating material are mounted in series, and the needle left at rest. A spark from a condenser some yards away influences the insulating properties of the body tested, as shown by a deflection of the needle, and becomes to some extent a conductor until given a tap, when it recovers its normal insulation. The Maison Besson exhibited a specimen of the Giraud thermopile stove. This is about 5ft. high and 2ft. 9in. diameter. The heat can be utilised for warming, besides which a current of four amperes at short circuit can be obtained. The E.M.F. at open circuit is 40 volts, but the output falls to two amperes at 20 volts in actual use; it furnishes 960 watt-hours in 24 hours, allowing a service of 33 lamp-hours of 8-c.p. lamps. The consumption of coke is about a franc per 24 hours, so that the kilowatt-hour is taken to cost 10d.

Portsmouth.—A public enquiry was held at Portsmouth last week by Mr. Arnold Taylor, Local Government Board inspector, principally with reference to the application of the town to borrow £60,000 for electric lighting. The town clerk said the original application for power to borrow for electric lighting purposes was made on a scheme prepared by Mr. Shoolbred, but that part of the resolution was afterwards revoked, and a scheme prepared by Prof. Garnett was adopted. Prof. Garnett, in explaining his scheme, spoke of the large extent of the area of compulsory supply, and said that wherever the stations were placed the extent of mains would be at least one mile. Besides this, the ratepayers could compel extension. Consequently a system which would permit rapid extension was required. This meant an alternating-current supply with a complete system of secondary mains in the districts of supply, with transformers situated in street boxes beneath the pavement. These could be placed opposite large premises, avoiding secondary street mains at these points. Ultimately there would be a transformer every 300 yards, while at first they could be few and far between. The high-tension current would never enter consumers' premises, and the loss due to transformers in every house would be reduced. As regards the station, it was proposed to occupy the site of the old amphitheatre opposite the Camber. The advantages of this site were that steam colliers could be unloaded immediately opposite the central station, and that sea-water could be obtained for condensing. The cost of the entire scheme he estimated at £55,300, but it was advisable to obtain permission to borrow £60,000, so as to cover the purchase of meters, the making of consumers' connections, and general working capital. Mr. B. C. Miller asked if Prof. Garnett had been engaged on similar work before, but Alderman Ellis said the Corporation and the Electric Lighting Committee were quite satisfied with Prof. Garnett's credentials. Mr. Miller said that as Mr. Shoolbred's report was carried and afterwards reported upon by Prof. Garnett, who drew up a further report only carried by the casting vote of the Mayor, he thought someone should be called in to report upon Prof. Garnett's scheme. Nearly all the schemes the Corporation had undertaken had proved failures, and he thought the higher cost of electric light would deter many from using the supply. The Mayor explained that his casting vote had been given, not as between high and low tension, but in favour of the matter being dealt with at once. He had been one of those who went to Bradford, and been delighted with what was seen there. But they found afterwards, not as the result of any communication with Prof. Garnett, but as the result of interviews with gentlemen who came down with the object of being engaged as engineers, that what was suitable to Bradford was not at all suitable to Portsmouth. Prof. Garnett, in answer to questions, said he had full belief the scheme would repay capital with interest, and furnish some profit. As to turbo-electric generators, such as were proposed, they had stood the test admirably within his own experience, including a term of six months while the Newcastle Exhibition was in progress. He was in charge of the electric lighting of the exhibition, which was a larger undertaking than the scheme now proposed for Portsmouth. At 6d. a unit the electric light was making headway more and more every year, against gas at 1s. 9½d. per thousand feet. In the course of further discussion, Mr. Manville, Prof. Garnett's associate as consulting engineer for the scheme, endorsed what the Professor had said, and Alderman Ellis said he was informed that the electric lighting company that was originally formed in Portsmouth had obtained orders for 16,000 16-c.p. lamps.

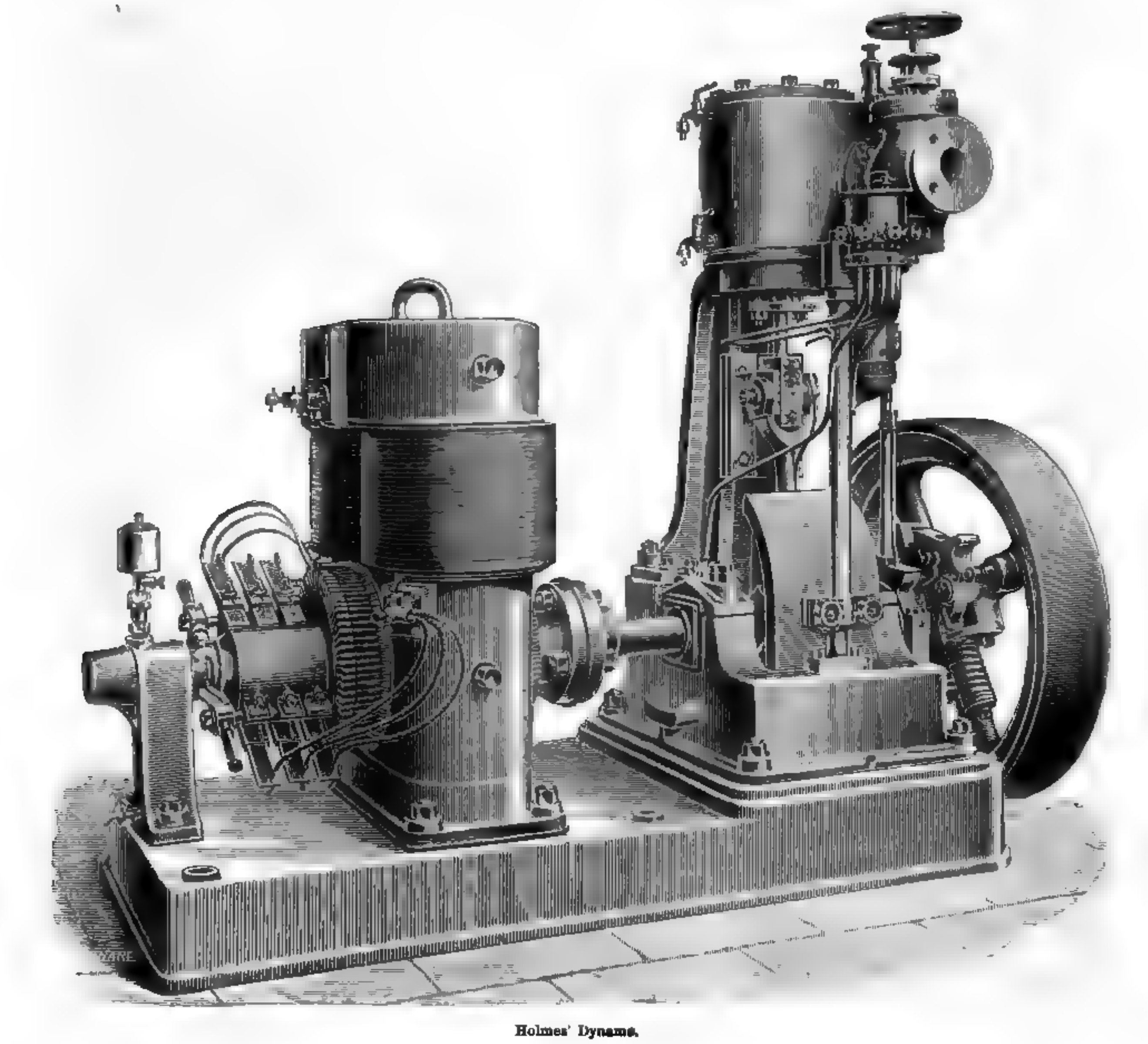
THE CRYSTAL PALACE EXHIBITION.

DIRECT-CURRENT DYNAMOS.—V.

BY R. W. WEEKES, WHIT.SCH.

The respective advantages of the different types of field magnets will need consideration under several headings, and I propose to treat each individual machine amongst those of similar type.

The principal electrical details to be considered in the design of good field magnets are that as little exciting power as possible shall be required, and that the armature reaction shall not have an injurious effect on the machine when working at full load. The ampere-turns on the armature can be considered in the armature core. Hence in the large machine the larger air gap mitigates the effect of the cross turns somewhat. The back ampere-turns are produced by the current in the wire lying between the lines *a a'*, *b b'*, Fig. 27. Their effect is simply to weaken the field, and hence they can be easily counteracted by compound winding, or some other method of increasing the field strength at full load. The symbols used in Fig. 27 may be new to some readers. The wires marked with a cross inside are those in which the currents flow up towards the paper, and in the others with the dot the current flows down. The small arrows denote the path along which a small north pole would be urged, and hence denote the direction and sense of the lines of force. The way in which the armature reaction affects the induction at the edges of the



Holmes' Dynamo.

two parts—viz., the cross and back ampere-turns. The cross ampere-turns are produced by the current in the wires lying under the poles and extending up to the lines marked *a a'*, *b b'*, Fig. 27. These distort the field, and tend to cause lines of magnetic force round the dotted path shown. The effect is that the induction at the polar surface is no longer uniform, but is weaker than before at the edge of the pole which the conductors approach, and stronger at the other edge. Consequently, the neutral axis is advanced, and the lead of the brushes has to be still further advanced to get sparkless running.

The cross ampere-turns, as will be easily understood, increase with the size of the machine, and the distortion of the field becomes much more marked. It must not be forgotten that the distortion is proportional to the cross ampere-turns multiplied by the polar area and divided by the distance between the pole and poles can be readily seen by these arrows. The neutral axis would be a little behind a line joining the points of brush contacts.

Another electrical consideration should be considered—namely, that of magnetic leakage. This loss is caused by the magnetic lines of force leaking across from one part of the magnet to another, and hence not passing through the armature. In very badly-designed machines worked at the saturation point, this leakage causes a constant waste of power which is very considerable. With well-designed dynamos it can be reduced to from 15 to 30 per cent. of the useful induction through the armature, but cannot be completely done away with.

The following figures, taken from Mr. Esson's paper on "Some Points in Dynamo and Motor Design," show what the leakage with the different types may be, but these values are high.

Name of machine.	Field.	Armature.	Leakage per cent.
Edison-Hopkinson	Two-pole upright type ..	Drum	32
Siemens	,, ,, ,, ...	,, ...	30
Phœnix	Two-pole inverted	Ring	32
,, ...	Double horseshoe horizontal type	,, ...	40
Manchester	Manchester type	,, ...	49
Victoria	Four-pole	Disc	40
Ferranti	Double magnet, multipolar	Coreless disc	100

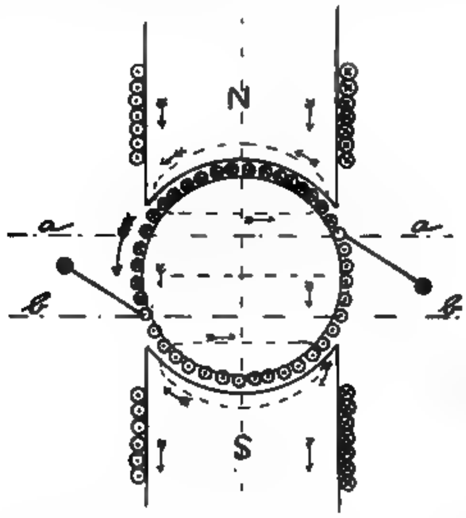
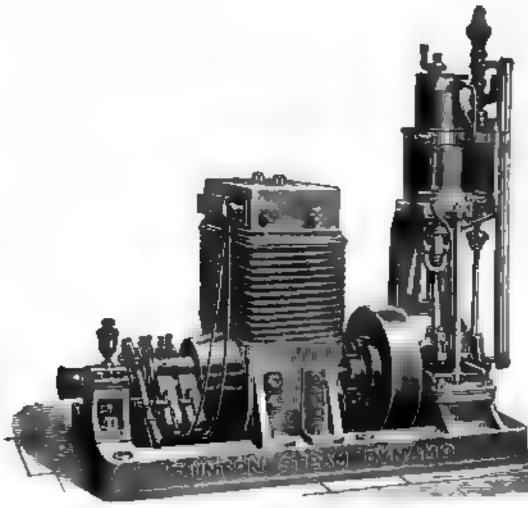


FIG. 27.

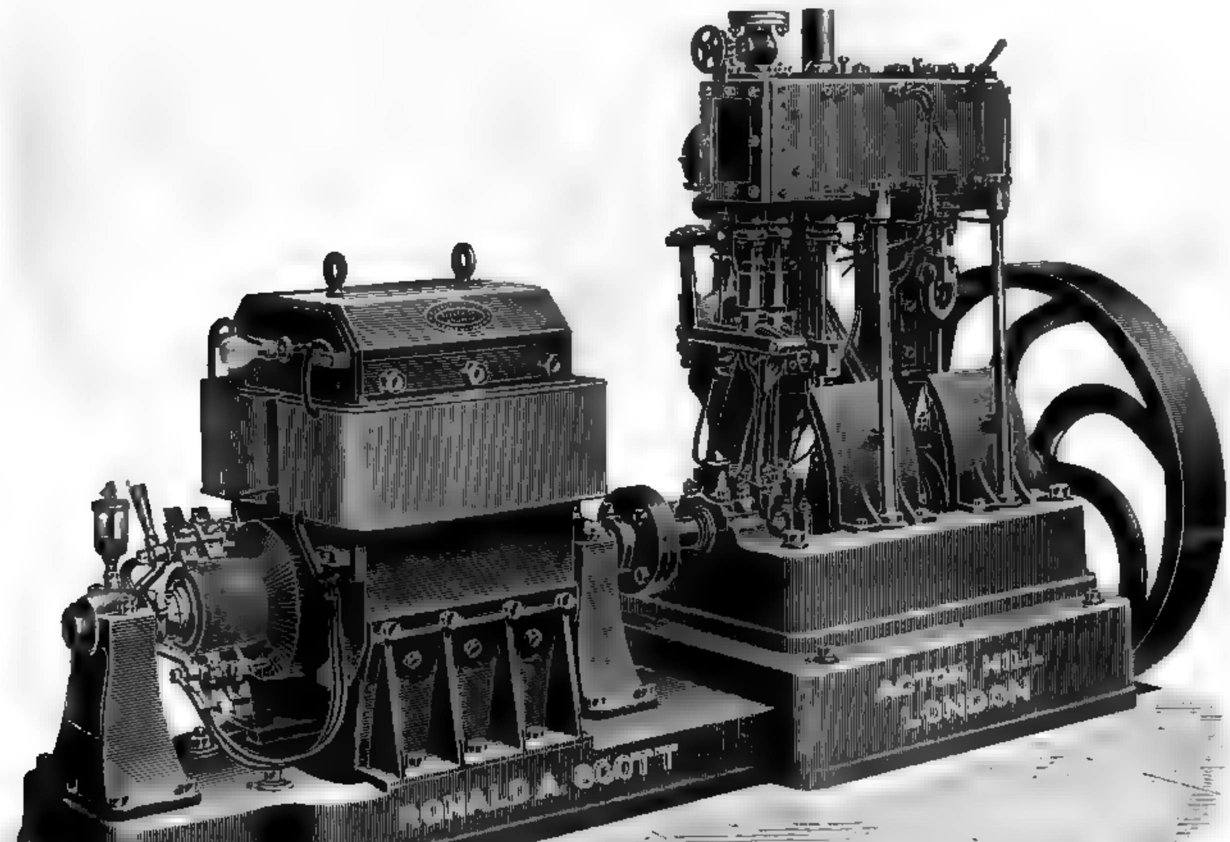
The question of the stray field has been taken up from the watchmaker's point of view by Mr. E. Edser, of the Royal School of Science, and he has measured the strength of the magnetic field around most of the dynamos shown at work. The results of his researches will, I understand, be shortly published in a paper before the Physical Society. The mechanical design of the magnet is a very interesting problem, and I propose to consider the following chief points: the ease of manufacture, the method of winding the exciting coils, and the arrangement for attaching the magnets to the bed-plate.

The Two-Pole Upright Type.—This make of field magnets was adopted in the first machines made by Edison, and perfected by the Drs. Hopkinson. They shortened the magnets and used the strong magnetic field, which has since proved to be the basis of all good designs. The type has many advantages. The pull on the iron of the armature coil due to the want of magnetic balance tends to lift it, and hence relieves the weight on the bearings.



Taunton Dynamo.

The centre of rotation is low, and this fact much simplifies the arrangement of pedestals, etc. It also gives a special advantage for coupling direct to engines, as there is no need to pack the engine up on a high bed-plate. This saves valuable space in shiplighting plants by reducing the height. For these reasons several firms use this type of field for coupled plant, although it is not the type they use for belt-driven dynamos. The chief disadvantage is that it is not easy to prevent magnetic leakage through to the



Ronald A. Scott's Dynamo.

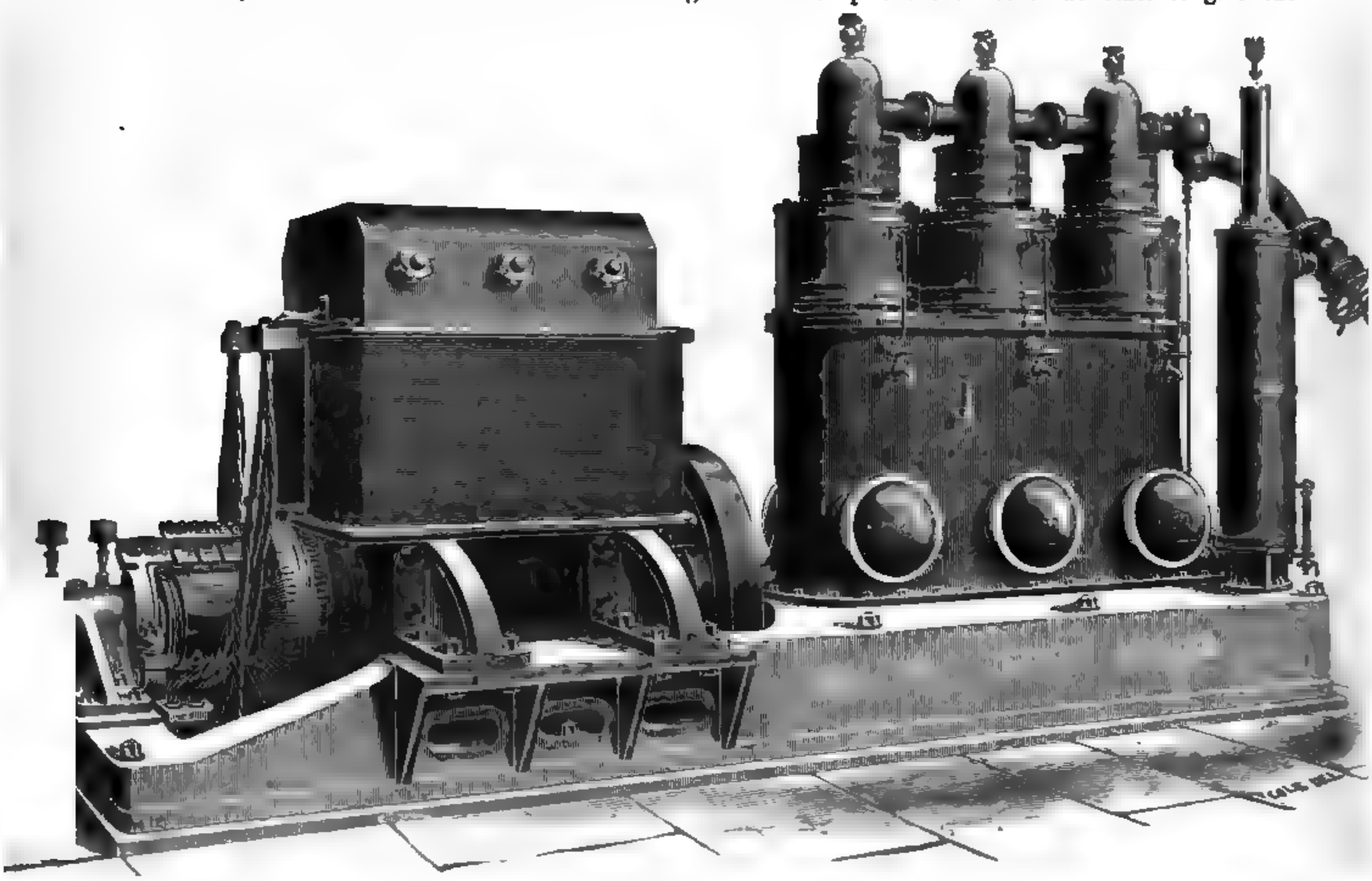
bed-plate. The various methods used to prevent this will be considered for each individual machine. In one case, measured by Mr. A. S. Ives,* in an Edison machine of this type, the leakage was found to be as high as 40 per cent.

Messrs. J. H. Holmes and Co. are the first firm on the list of those who use this upright type of field. Their dynamo is exhibited coupled direct to a Browett-Lindley engine for shiplighting on the single-wire system. It will be seen in the list that this machine stands high both for weight and floor-space efficiency. The magnets are made of wrought-iron forging 10in. diameter, which fit into cast-iron pole-pieces and yokes. The special feature of the design is that all the machining required is circular, and can be done either in a lathe or a boring machine. The magnets rest on zinc sole-plates, and the whole of the frame and armature core is insulated from the bed to give special safety against leakage. This is not absolutely necessary, but when the single-wire system is used, making the ship the return, it is a wise precaution. The exciting coils are of circular section, and hence take much less time to wind than coils of rectangular section; also as a circle includes the largest area of any figure having an equal perimeter, a considerable saving of copper is effected. The bed-plate has a longitudinal gap in the centre to reduce the magnetic leakage.

The Newton Electrical Engineering Company have removed their dynamo of this type, of which I have given the particulars, on account of defects in the engine to which it was coupled, and replaced it by a smaller ship-lighting plant. The magnets were made of rectangular wrought-iron slabs mounted on a high sole-plate of brass, and were compound wound. The armature was of the Gramme ring type, but I understand that this firm will in future use the drum winding and the Kapp connectors in machines of this size. Although coupled direct, the second dynamo bearing was retained, and this accounts for the lower output per square foot of floor space.

Messrs. Ronald Scott and Co. also show a coupled plant with this upright type of field magnets. It is being used every evening to supply the current for the whole of the search-light displays carried out by this firm, and is often to be seen working above its nominal output, and then runs cool and sparkless. The magnets are very similar to those last described, and are mounted on a brass sole-plate. The bearings are made adjustable by means of a spherical surface on the bushes, as described before. In spite of the use of the fourth bearing the floor-space efficiency is good, and it will be seen that the useful induction in the magnets is not high.

Messrs. Siemens Bros. and Co. have adopted this type of field for all the direct-coupled dynamos, and exhibit a number of them lighting different parts of the Exhibition. The dynamo of largest output is shown on their stall, but it is to be removed shortly to light an exhibition at Manchester. It has most massive wrought-iron magnets, as will be seen from the list, and the armature is of unusual length. The armature winding is a speciality, there being three distinct sets of conductors and commutator segments, which are connected in parallel by the brushes. The brushes are made of four ordinary copper gauze brushes placed one above the other to give the necessary arc of contact and flexibility at the same time. The distorting effect of the armature must be very great with such a large current-volumes and polar surfaces, but the machines work wonderfully well. I was privileged to inspect a similar armature which was run at the Naval Exhibition last year, and the commutator has not worn perceptibly with the six months' work. All the machines are direct coupled to Willans engines, and in every case the second dynamo bearing has been deemed unnecessary. It is especially worthy of note how in these dynamos the output per weight falls with the increase of the total output. This is due in a certain degree to the fact that lower inductions are used in the larger machines, but is certainly a point in favour of multipolar machines. The bed-plate of these machines are specially designed to prevent leakage of the lines of force. The magnets are supported by gunmetal stays fixed on to the flat surface of the bars. The lower parts of the poles then come in a large gap in this bed-plate in such a position that the tendency for the lines to leak into the bed-plate is much reduced. These details can be seen in the adjoining block of the large machine made by Siemens Bros. and Co.

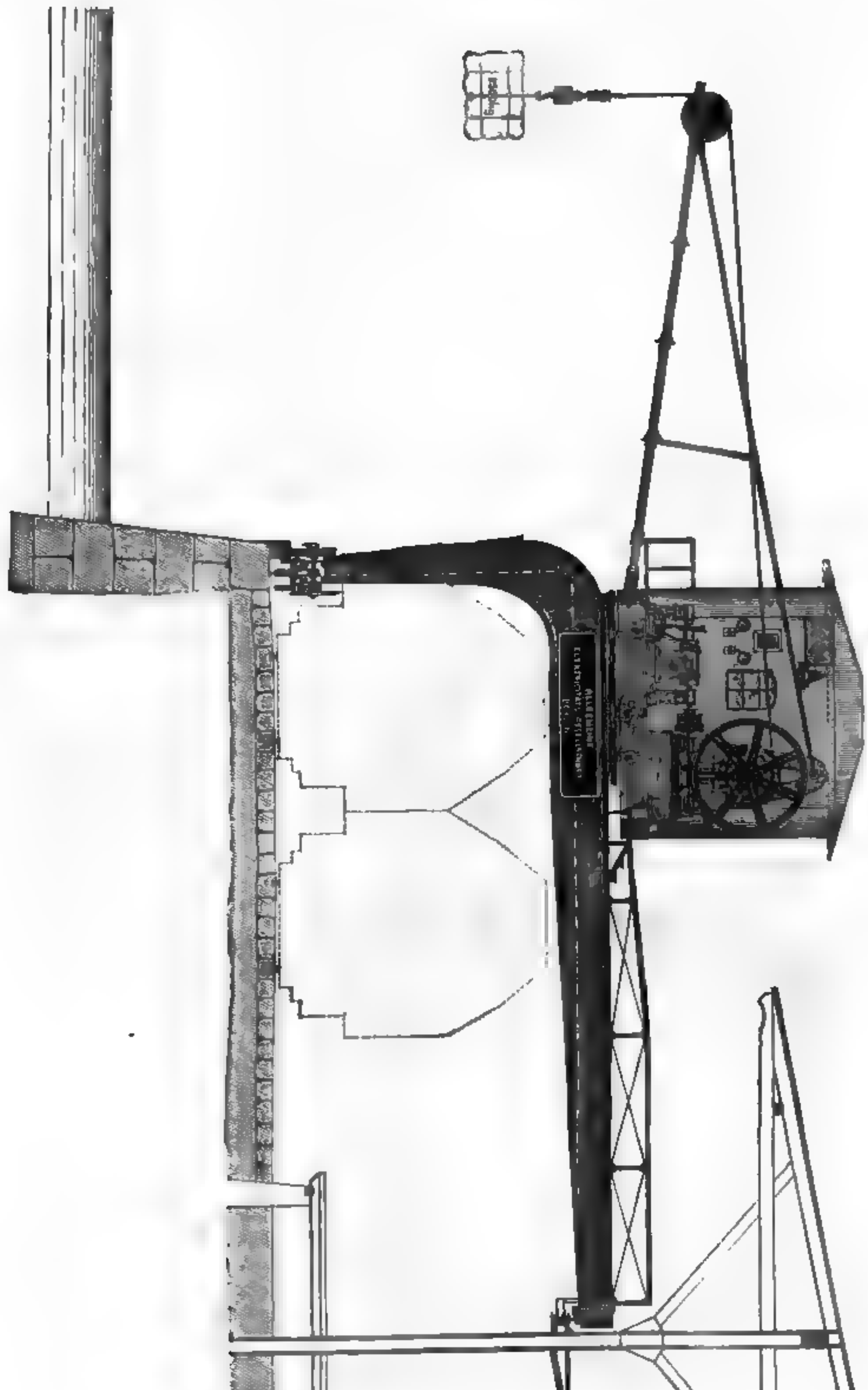


Siemens Dynamo.

* *Electrical World*, March 2, 1892.

THE ALLGEMEINE COMPANY'S ELECTRIC TRAVELLING CRANE.

We have already mentioned an application of electrical transmission of power by the Allgemeine Elektricitäts Gesellschaft of Berlin (London house, Keys' Electric Company, Limited) in an electrically-driven dock crane for the harbour quays at Hamburg. This installation we are able to illustrate and describe in detail. It is worthy of attention, as it may be looked upon as a further step toward the development of a new field of great importance to the extension of the transmission of electrical power. The travelling crane, which is capable of carrying about 2½ tons, was put in operation in November last for loading and discharging large ships, and it is interesting to note, with reference to the immediate prospect of the general adoption of electrical power to hoisting machinery, that it has continued to work without interruption ever since, in spite of the unpropitious and wintry weather.



The Allgemeine Company's Electric Travelling Crane.

The crane, as shown in the illustration, is constructed upon the now universally-acknowledged principle of the traversing crane, and stands upon a traversing framework, which is sufficiently high and wide to permit the passage under it of two lines of railway or waggon traffic, and it terminates alongside a goods shed, so as to pass the goods into and out of the latter. The dimensions and points of its construction are as follows: Safe load, 2,500 kg. (nearly 50cwt.); total height of lift, 13·75 m. (say, 45ft.); projection of the jib—*i.e.*, distance from the centre of the crane to the centre of the sling hook, 10·75 m. (35ft. 3in.); vertical speed, 1 m. per second (197ft. per minute); traversing speed, 2 m. per second (394ft. per minute).

In the construction of the crane it was deemed advisable that wire rope instead of a chain should be used, and i the winding gear spur or bevel -

for the sake of silent running. The handling of the crane was to be as far as possible like that of hydraulic or steam power cranes in which it is possible to raise or lower the load during the traversing of the crane. The station also provides the light for the harbour, and was erected some time ago by the Allgemeine Elektricitäts Gesellschaft. The current is brought from the generating station through copper rods carried along the outside of the shed; cables pass through the hollow pivot of the crane and lead to the controlling gear. Around this pivot, which is seated in a turn-table, revolves the whole winding and traversing mechanism of the crane, protected by a cabin with windows and mounted upon an iron platform. Each set of these gears is entirely distinct, each having its own electromotor, and each being controlled by its own particular lever.

The turning of the crane is effected by means of an electromotor which drives one of the three guide-wheels under the turn-table by worm gear. The worm spindle can be stopped at any moment by a powerful brake actuated by the steering lever when this is in its midway position, thus the turning motion is controlled with precision. To obviate all liability of damage to the spindles from the swiftly-rotating armature, an elastic coupling, a so-called "wire brush coupling," is used, which acts when the brake is applied, permitting the coupled parts to glide past each other and allows the armature to come to rest after a few revolutions. For a similar reason, the above-mentioned guide-wheel, running on a smooth path, was chosen in place of a toothed rail and spur wheel; for breakdowns were to be feared with the latter through the rapid turning of the long derrick. There is, however, always a means afforded to the driver of modifying the speed of the crane, inasmuch as the motor is series-wound. Further, for this and the backward and forward traversing of the crane generally, a special controlling arrangement is now used similar to that on the tramway motors on the A.E.G. system.

The 40-h.p. electromotor of the hoisting gear is shunt-wound and connected, like the above, by a "wire brush coupling" to a worm spindle, which has a powerful brake actuated by the respective controlling lever, as in the former case. The reversal of the direction of motion is also attained electrically, by reversing the armature current; the starting resistance is switched off simultaneously with the movement of the controlling lever. This, in its mid position, entirely cuts off the current from the motor. By pulling the lever backwards the current flows first through the field magnets, then in increasing quantity through the armature, while simultaneously the brake of the worm spindle is released and the load begins to ascend. On the other hand, if the lever is pushed over from the midway position in the forward direction the manipulations are the same, but before the armature receives its current the direction of motion is changed, and the whole hoisting gear now runs the opposite way, so that the load descends. The worm now tends to drive the armature, but the shunt-wound motor does not permit it to force it beyond its normal speed, so then the armature acts as an electric brake, and sends the current back into the conductor instead of consuming energy.

Excellent as is the action of this electric brake, and although in comparison with other methods (water or steam) it shows a great saving—up to even 20 per cent., according to circumstances—a dangerously rapid descent of the load might take place in the event of a rupture of the circuit through this brake. To provide against such an accident, a second electric brake is furnished, which is equal to any possible contingency. Alongside the hoisting drum round which the wire rope is coiled, and connected to it, is a brake wheel, the brake blocks of which are so weighted that they would be permanently pressed against the brake disc, if there were not on the opposite side a powerful electromagnet to hold them back, so long as it is influenced by the passage of the main current. Any interruption of the main current makes this electromagnet inoperative, permits thereby the brake blocks to fall against the disc, and instantly grips the whole hoisting gear, thus preventing further motion.

The advantages of this electric crane compared with steam cranes are very considerable. Firstly, the commercial efficiency of electric motors is on the whole higher than that of the steam motors of equal power hitherto employed on the Hamburg quays. With all other motors the efficiency falls off continuously from various causes, such as the difficulty of keeping pipe-joints tight. The current used by the electric motors remains always very nearly proportional to the demand of the moment, whereas similar economy is impossible with the direct-action steam cranes hitherto in use, because the principle of expansion is not brought to bear in these. Furthermore, a saving (amounting sometimes to nearly 20 per cent.) is effected through the return current when the load is taken off the crane, which is not obtainable in the case of steam power. Again, with an electric system having proper insulation, the degree of efficiency may always be calculated beforehand, while considerable losses through long steam-pipes, especially in winter, in consequence of the cooling in cylinders and pipes in a steam system, are unavoidable. Lastly, a properly constructed electric system requires few repairs, which are always so great an item with steam cranes.

The crane has been working without a hitch for more than four of the least propitious months of the year, and has now been taken over by the dock authorities. The Hamburg harbour authorities may be congratulated on the outcome of their enterprise, and the Allgemeine Company upon the success assured by their skilful design and construction.

SINGLE-REDUCTION MOTORS.*

BY GEORGE K. WHEELER.

All practical street railway men appreciate the necessity of having a motor that shall have the greatest possible degree of self-protection from outside injury. This necessity was evident by the number and severity of the storms of the last few years, and it has been the aim of electric manufacturers to design a motor that would meet the requirements of ordinary street railway service, and so constructed as to be perfectly protected within itself, and to reduce the number of wearing parts, reduce the weight of the motor, and construct a frame of such strength that breakage would be impossible, and to provide a more perfect magnetic circuit than that found in the double-reduction motors. The important problems to be solved in making a successful single-reduction motor are as follows:

1. Electrical and mechanical simplicity.
2. Slow speed and powerful torque.
3. Protection of field and armature from dust and water.
4. Accessibility of all parts of the motor so as to render it easy for repairs and adjustment.
5. High commercial efficiency at all speeds and loads.
6. Reduction of weight per horse-power developed with a view of lighting the load that must be carried at all times.
7. Small expense of maintenance.

There have been various types of single-reduction motors placed upon the market during the past 15 months, and I must say that some of them have not fulfilled the above requirements. It is my opinion that much better results are obtained with a two-pole single-reduction motor than by the four-pole, for the reason that it is much lighter, simpler in construction, has a smaller commutator, half the number of bobbins on armature, also half the number of brushes, and is much more economical to maintain. One of the leading electric manufacturers has produced a motor that I think meets all the requirements for ordinary street railway service; this motor is 15 h.p., weighs about 2,000lb. complete, including gear, pinion, and gear case. The motor frame is constructed of two castings of steel, clamped together by bolts at the front and back, the axle brasses being held between the two parts. The armature bearings are cast in one piece with the lower half of the frame, and are provided with caps so that the linings may be inspected or renewed without disturbing the other parts of the machine.

The frame is hinged together at the axle end, so that the upper half may be raised if desired. The lower half of

* Paper read before the Chicago Electric Club, March 27, 1892.

frame is so constructed that it is perfectly waterproof up to the centre line of armature and axle bearing. All the metal in the frame forms a part of the magnetic circuit, and dead-weight is thereby avoided. The armature is a combination of the Gramme and Pacinotti type, and so constructed that it is entirely iron-clad. The iron core is a ring with projecting teeth solidly fastened to the shaft. The coils are wound beneath the teeth and firmly held in place by wooden wedges. It is not necessary with this form of armature to use the mica, insulating paper, canvas, and German silver bands. The winding is continuous, and all joints are made by electric weldings, no solder being used in any part of the armature. The winding is such that there is no crossing of wires, and as it is below the surface of iron core, it is protected from any mechanical injury. This form of armature permits of much less clearance between the armature and pole-pieces, and the smaller air gap materially decreases the magnetic resistance of the circuit. This certainly means less weight and less heating of the field spool, and that a smaller motor will perform more work on account of greater efficiency. The field coil (there being but one) is placed at the top of the motor, and in this position exerts upon the armature a solenoidal pull, so proportioned that under normal load the armature is lifted from its bearings.

I have had an opportunity of inspecting a set of armature bearings that had been in use upon a motor of this type for several months, and the tool marks in the bearings had not been scored with the exception of a small spot on the bottom and top of bearings, thus demonstrating that the wear on brasses is reduced to a minimum. The armature pinion and axle gear are made of steel, of ample width of face, and are run on an oil-tight case in order to ensure free and continuous lubrication, and to exclude dust and grit. As to the exact life of gear and pinion thus enclosed I am unable to state accurately, but I know of single-reduction motors that have been in operation since May 1, so enclosed and running in a light weight of grease, which up to the present time do not show wear of more than $\frac{5}{1000}$in. It would certainly seem by this that the expense of maintaining the gear and pinion for two motors per car could not exceed 10.00dols. per year.

The tendency of modern improvement in railway motors is to diminish the gearing, and I do not think that anything is to be gained over the double-reduction motor by placing two sets of gears and pinions one on each side of a single-reduction motor, as it not only increases the friction losses, but adds an additional weight to the motor, and if the motor frame and armature shaft are properly constructed, there is no liability of straining or breaking either by reason of placing the gear and pinion on one side only. It is stated by a number of competent electrical engineers that the placing of one motor on a truck is ample for all ordinary street car service. By experience I have found that with a truck having but one motor attached to one axle, that the wheels on the axle to which the motor is attached do not break as quickly as the free wheel, and flats are thus formed on the free wheel on this account; also that it is a difficult matter to ascend grades over 3 per cent., and that it is next to an impossibility to operate a car so equipped during the winter months. It is also advocated that the proper method is to gear a single motor to both axles, this, in my opinion, is open to serious objections. In gearing a single motor to two axles of a truck it is almost impossible to keep wheels perfectly true—that is, one set of wheels will perhaps wear more than the others on account of the variation in the quality of the iron; and as soon as one set of wheels is in the slightest way different from the others, a bad action takes place between the driving gear and wheels, for the reason that one wheel is trying to run faster than the others, which, of course, naturally causes one set of wheels to be dragged along until that distance has been overcome, and when the wheels start anew, the gears are in a short time thrown out of mesh with each other. It will be understood that in order to make a successful gear driven by a single motor, it is necessary that both sets of wheels travel with exactly the same speed over the rails, and that the truck on which the motor is mounted must be perfectly rigid so that the gear will at all times mesh with each other. In practice, this has been found almost impossible, especially where heavy work is required, and a large number of curves are to be found, and also where the track is in bad condition, excepting possibly when the wheels on the truck are perfectly new, and track in good shape, and the curves very liberal, but it will be found if one set of gearing is disconnected, that it will require from 15 to 20 per cent. less power to operate. It is for these reasons that I believe the best results are obtainable by connecting a single motor to each axle of a truck. It may be argued that there is twice the liability for the trouble where two motors are used, but experience proves that this is not exactly so, for by this method you obtain the proper traction and benefit of all wheels, and in case of extra load you have ample power to operate the car under all conditions of service, and in case of injury to any part of one motor, it can be disconnected and the car operated until an opportunity offers to make the necessary repairs.

A single-reduction motor should be so constructed as to give the greatest possible distance between the bottom of the motor and the top of rail. With the best form of motors which have up to the present time been constructed, the greatest distance obtainable between a 15-h.p. motor and top of rail is 4½in. when placed on a wheel 30in. in diameter. I strongly recommend the use of larger wheels, either 33in. or 36in. in diameter. With a motor mounted on 36in. wheels, this will give a clearance of 7½in., which is more than ample to clear ordinary track obstructions, and if the motor is thoroughly protected in its frame, it will not be necessary to use motor pans, which have been a necessary evil in connection with double-reduction motors.

It may be stated that a car equipped with 36in. wheels require an excessive amount of current to operate, but this is not a fact. On a test which I made more than a year ago on a car equipped with 36in. wheels and a car equipped with 30in. wheels, the same motor equipment and car of same length and weight, operated over the same length of road on the same day and by the same man, total length of line being 16 miles, it was found that the car equipped with 35in. wheels required about ¾ h.p. more on an average than the car equipped with 30in. wheels, although the 36in. wheel car required more current in starting and climbing grades, but it would run longer on the level by momentum, and thus average up the current consumption. With the present form of single-reduction motors I think that the 33in. wheel is of ample size.

On tests which have been made with the best types of single-reduction motors, they have been found to be from 8 to 10 per cent. more efficient than the double-reduction, and are capable of attaining a much higher speed under various conditions of service. On a recent test which I made on an over-country road, being some 11⅛ miles in length, the car being 34ft. in length, and with 25 passengers, total weight of car being 23,700lb., car equipped with double trucks having two 25-h.p. single-reduction motors to each car, the maximum speed attained was 32 miles per hour, this car climbing grades of 4 or 5 per cent. at the rate of 17 miles per hour, and on a car 16ft. in length, equipped with one 15-h.p. single-reduction motor, the maximum speed attained was 25 miles per hour on the level, and the car in climbing grades of 4 and 5 per cent. would not attain a speed of over five miles per hour.

By the use of single-reduction motors the cost of maintenance and operation will be greatly reduced on any road so equipped for the reason that the number of parts have been greatly reduced from that of the double-reduction, and its efficiency greatly increased. I am of the opinion that the single-reduction has come to stay and will continue to force its way to the front, and eventually supersede the double-reduction motor with which the earlier roads were equipped.

Electric Stampers.—The Chicago post office has four electric stamping machines, each of which will stamp 28,000 letters an hour. The four machines perform the work of 16 men, and stamp with very great clearness. The United States Postal Department has contracted [illegible] these machines, which will be [illegible] principal offices throughout

THE

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CONTENTS.

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BOUND VOLUMES.

Vols. I. to VIII. inclusive, new series, of "The Electrical Engineer" *are now ready, and can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.*

ST. PANCRAS.

The ceremony of Wednesday last, informal though it may have been, is one deserving of more than passing record. The vestries of London are not usually regarded as progressive institutions; in fact, their days are said to be deservedly numbered because bumbledom and backwardness are understood to be synonymous. But many a dark cloud has a silver lining, and it would often prove difficult for those who criticise bumbledom to do the work better, or to keep abreast of the times as well. Although it may not seem so, the very fact that the election of vestries claims little interest is one of the greatest proofs of general efficiency. Happy is the vestry that hath little history, but there are times when vestries, as well as larger constituencies, make history. St. Pancras is passing through such a time with its lighting projects. Most local authorities in and around London—all, in fact, except St. Pancras—have been satisfied to allow, more or less continuously, any private company to experiment, and, if possible, to prove the advantages of electric lighting. St. Pancras, on the other hand—with a far-sighted policy according to our opinion, with a temerity akin to rashness in the opinion of many people—decided so far back as 1883 to keep the lighting in its own hands. In 1883, however, we in England had too little knowledge to satisfactorily instal central stations. The authorities of St. Pancras either knew of this ignorance or were duly advised to wait—and wait they did—till knowledge came, and it was possible to ensure success. Proceeding under competent advice, that of Prof. Henry Robinson, the St. Pancras authorities ultimately proceeded with their first station, which has been satisfactorily completed, and, what is more to the point, its whole output is engaged. It was to commemorate this fact that the Electric Lighting Committee invited the members of the Vestry and other friends to visit and examine the station on Wednesday.

It is, of course, out of place here to describe the station, but we may say that it has been designed by Prof. Robinson to supply current for 10,000 incandescent 16-c.p. lamps for interior lighting, and ninety arc lamps of ten amperes for street lighting. The central station is entered from Stanhope-street, N.W., and occupies part of a freehold site of 21,000 square feet, acquired for £10,000 by the Vestry. The buildings consist of an engine-house 106ft. by 26ft., a boiler-house 40ft. by 14ft. 6in., and various smaller rooms for testing, stores, etc., and an underground water-tank to hold 170,000 gallons. The five boilers are of the Babcock-Wilcox type, and supply steam to eleven Willans-Robinson triple-expansion engines. The engines are coupled direct to Kapp dynamos, built by Johnson and Phillips. The dynamos are six-pole continuous-current machines. Nine are wound for an output of 680 amperes, at pressures varying from 112 to 130 volts. Official trials at Thames Ditton with the combined apparatus showed a steam consumption of 18·65lb. per electric horse-power per hour. The official trials of the boilers showed an evaporation of 9·747lb. of water per pound of coal, so that under the conditions

existing when these trials were made, the plant combination—*i.e.*, the combination of boiler, engine, and dynamo—gave an electrical horse-power, or 746 watts, for a consumption of 1·9134lb. of coal per hour. Under similar conditions, 1,000 watt-hours—the Board of Trade unit—means the consumption of 2·6lb. of coal. The arc lamps used are of the Brockie-Pell type, and, together with the standards on which they are placed, were supplied by Messrs. Johnson and Phillips. The supply of current from the station commenced on November 9th last year, so that within six months of the opening the full capacity of the station has been reached. This result is highly satisfactory. The continued existence of this station will help to solve many problems, not the least of which is whether local authorities should become their own producers or relegate their powers to private individuals or companies. Prof. Robinson has it in his hands to influence them one way or the other to a large extent. The details of capital expenditure, of maintenance, and of income should be kept with the most rigid accuracy. In the heart of London, where initial cost is excessive, where coal, water, labour, and stores are as costly as in most places, if the production of electrical energy under the auspices of a local authority is satisfactory, no doubt many such authorities will follow the example. Great praise is justly due to Mr. E. Gibb, the clerk to the Vestry, for the indefatigable labours he has gone through to bring about a consummation of this work, and he, with the Lighting Committee of the Vestry, must be congratulated upon the success which has so far attended their efforts.

SOUTH AMERICAN CABLE.

Probably the most satisfactory investment that has for some time past been offered to investors is that of the South American Cable Company, whose prospectus appears in another column. It has become a well-recognised fact that cable property is one of the most stable that can be obtained. North America is connected with Europe by a large number of cables, but South America has hitherto been inadequately connected. Although troubles, political and otherwise, somewhat tend to keep back the progress of South America, there is not the slightest doubt but that the total volume of trade is a continually increasing one, and necessitates greater telegraphic facilities. This new cable will, so to speak, tap a new field. It will, besides connecting Europe, give a direct line from Africa. It will be constructed at a comparatively little cost. The capital is not watered like that of some of the older companies, so that a moderate return will give a fair dividend. The cable is to be laid by a firm of the greatest experience, and under engineers of the greatest ability. With the exception of the Pacific scheme, this is one of the links in the cable system which remains to be completed. It will be seen that several Governments are more or less interested in this cable, so that the estimated revenue given in the prospectus is not likely to be overstated, but more probably will be exceeded.

THE NEW TELEPHONE COMPANY.

The New Telephone Company, with offices at 110, Cannon-street, is actively pushing its canvass for subscribers. As is well known, this company advocates the twin-wire system, and from experience gained at Manchester maintains that most of the evils besetting the system as now applied in London are thereby avoided. Both from a scientific and from a practical point of view the twin-wire system is that which approaches most nearly to perfection. The success of this company will gladden the hearts of those interested in traction work, for instead of one company catering for public patronage fighting another company also catering for public patronage, the various interests will not clash to anything like the same extent as do those of the existing telephone companies and the electric traction companies in and around London. We shall now see what the National Company will do in the face of a competition which gives a better article at a lower price. The new company will take the first 5,000 connections at £12. 12s. per annum, on a one, two, or three years' agreement, and no subscriber will be asked to pay anything till 3,000 instruments are actually in connection through the exchange. After this number of instruments are connected, the subscriptions will be payable in advance for the ensuing year.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

INCREASING THE SUPPLY.

SIR,—Under the above heading, in your issue of the 15th inst., you point out that the reluctance of would-be consumers of electric energy in residential districts to have their houses wired and connected to the mains of electric supply companies in London, is mainly due to "the cost of outlay for the wiring and fittings"; that many hold their houses on short leases, and that often leases contain restrictive clauses with respect to alteration of gas mains, etc., in favour of the landlord; and that "the electric light fittings, as usually laid in a house, come under the heading of fixtures, and as such therefore become the property of the landlord on the expiry of the lease."

I am interested in the formation of an electric light company, and have been brought face to face with these very difficulties. It is a small but busy country town we purpose lighting, and the tradesmen and other inhabitants are anxious to have the electric light. These, almost without exception, have incurred great expense in gas fittings, etc., and several have done so quite recently, therefore they hesitate to incur the expense of further outlay on wiring and fittings for electric light, although they are anxious to have the light, and the fact that the landlord's property would be increased in value at the tenant's expense makes them the more reluctant to incur the necessary outlay.

To meet this difficulty I propose to wire the houses and business premises free of cost to the customer, charging a rental to cover interest on the outlay, depreciation, and a small profit to the electric light company. When the company has been repaid the first cost, plus interest, etc., I then propose to reduce the rental to a nominal sum, to cover depreciation or maintenance, etc., and a small charge to uphold the company's claim to the property, which would really amount to profit. By this means consumers will be encouraged to come on and take the company's current, the company looking to [illegible] mainly for its profit.

favour amongst the inhabitants, who have largely promised to become consumers and to take shares, also, in the company.

Now, of course, the question naturally arises, In what manner will the interests of the company be protected against the landlord? The reply is, By Section 25 of the Electric Lighting Act, 1882, which states:

"Where any electric lines, meters, accumulators, fittings, works, or apparatus belonging to the undertakers are placed in or upon any premises not being in the possession of the undertakers for the purpose of supplying electricity under this Act, or any license, order, or special Act, such electric lines, meters, accumulators, fittings, works or apparatus shall not be subject to distress or to the landlord's remedy for rent of the premises where the same may be, nor to be taken in execution under any process of a court of law or equity, or any proceedings in bankruptcy against the person in whose possession the same may be."

Obviously, from the above the wiring and fittings, if carried out by the company in the manner I suggest, would remain the absolute property of the company or undertakers, and the landlord of the premises would have no lien or right over them, and the company would be free to remove the same at any time in accordance with the company's contract with the consumer. This, of course, applies only to such cases as do not contain the restrictive clauses, above referred to, in the leases.

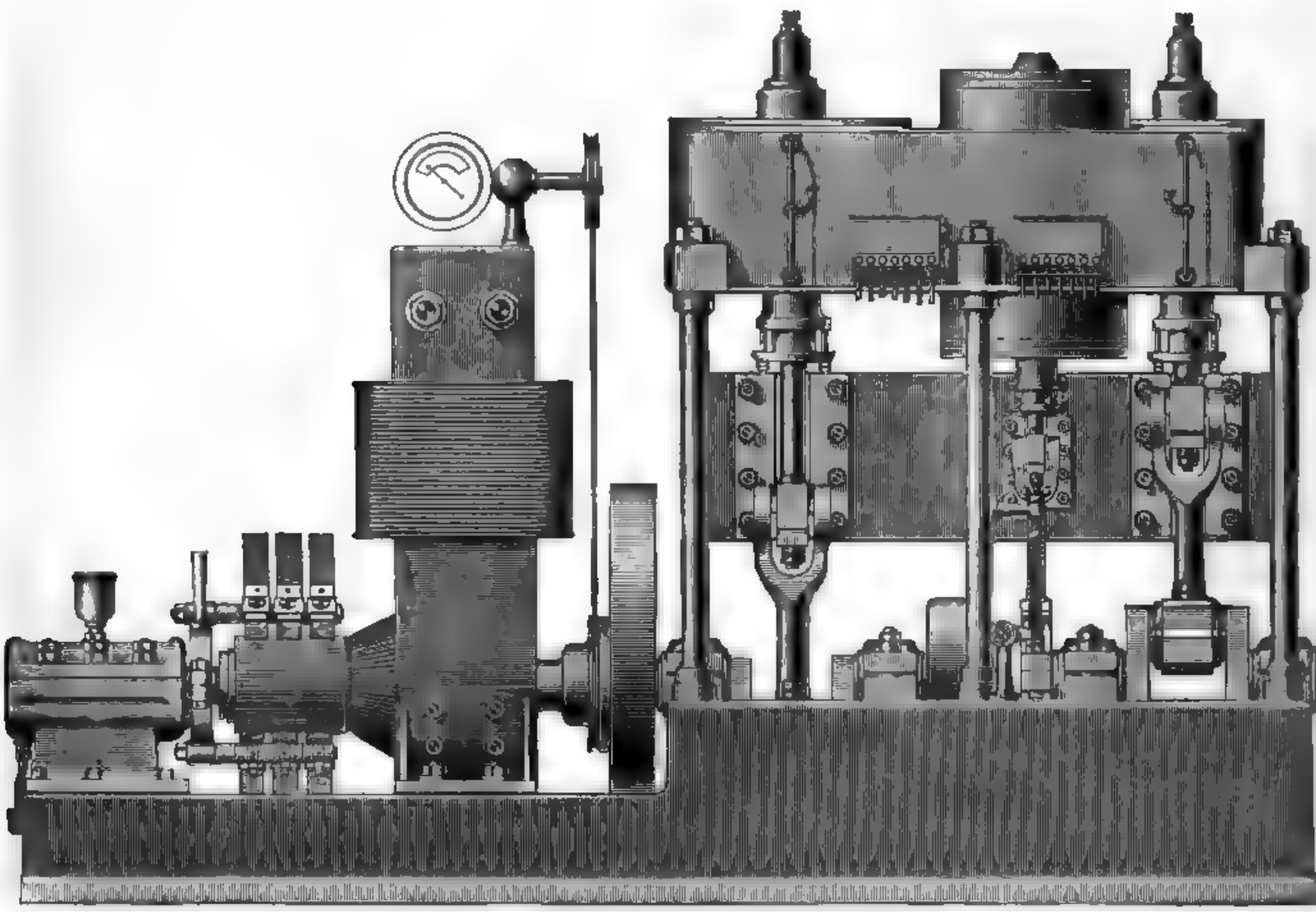
When the lease is so drawn as to require the permission of the landlord to alter the gas fittings and it is not worth the while of the tenant to trouble in the matter, because of the approaching expiry of the lease, and at the same time the tenant is desirous of having the electric light, and would become a consumer if the house were wired and connected to the company's mains, in such case it might be worth the undertaker's while to effect an understanding with the landlord to wire the house whereby the fittings, etc., would remain the property of the undertakers. The landlord would, in the majority of cases, see that the letting value of his house would be enhanced by having it fitted for electric light, and that he would have some guarantee that his house would not be torn to pieces through the fittings, etc., remaining the property of the undertakers, as it would be in the interest of the undertakers to allow the same to remain intact to secure the custom of the incoming tenant, who, of course, would be charged a rental for the use of the same. Thus, such a system would serve the interests alike of landlord, tenant, and undertaker, and it would most unquestionably conduce to a rapid growth of the electric lighting industry.

THOS. H. WILLIAMS, A.M.I.C.E.

London, S.W., April 21, 1892.

COMBINED ENGINE AND DYNAMO.

We illustrate herewith the combined engine and dynamo plant constructed by Ernest Scott and Mountain, Limited, and specially designed to conform to Admiralty requirements for use on board warships or in places where space is limited. The engines for all sizes of plant, with the exception of the smallest, are of the compound type, and are constructed for a working pressure of 160lb. to 200lb. per square inch, but they are capable of giving the full normal output at a pressure of 100lb. per square inch. The cylinders are of cast iron, lapped with sheet steel, and fitted with all necessary drain-cocks, relief valves, and indicator plugs. Steam is admitted to both cylinders by a double piston valve placed between the two cylinders and worked by one eccentric and rod from the crankshaft.



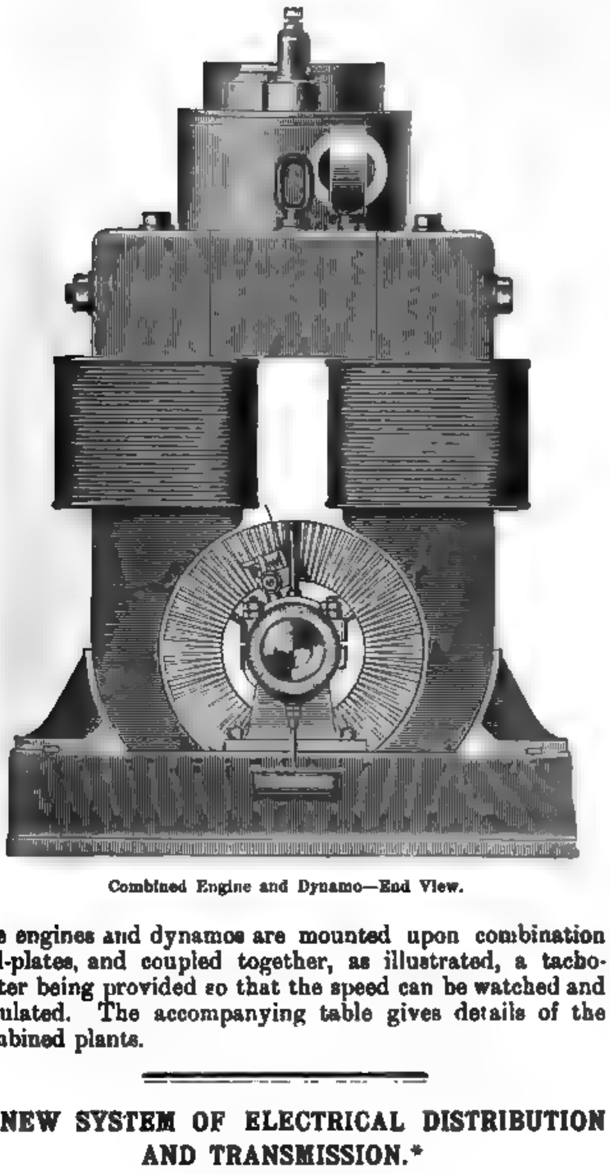
Ernest Scott and Mountain's Admiralty Pattern Combined Engine and Dynamo.

The crankshafts, piston rods, eccentric-rods, valve spindles, and front columns are of steel; all bearings are adjustable and of extra length, lined with white metal, and special lubricating arrangements are provided, so that the engine is capable of running continuously without attention. The governor is placed upon the crankshaft, and so arranged that the speed can be adjusted whilst running.

The dynamos have been designed to meet Admiralty requirements as regards heating, output, and speed; they are compound wound and self-regulating. The field magnets are of the softest wrought iron, carefully annealed; the magnet bobbins are wound in separate cases, so that they can be readily removed. The armatures are of Scott and Mountain's special type, enabling them to be readily repaired in case of

Type.	Output in watts.	E.M.F.	Amperes.	Speed.	Engines.			Approximate over-all dimensions.			Approximate weight.
					Diameter of H.P. cylinder.	Diameter of L.P. cylinder.	Stroke.	Length.	Width.	Height.	
								ft. in.	ft. in.	ft. in.	cwt.
1	3,600	60	60	450	[illegible]	7	5	6 0	2 9	4 9	10
2	8,000	80	100	350	5	9	5½	6 9	3 0	5 0	[illegible]
3	16,000	80	200	325	6½	12½	6	7 6	3 3	5 3	56
4	24,000	80	300	325	7½	14	7	8 3	3 8	5 8	80
5	32,000	80	400	325	8½	15	8	9 0	4 0	6 0	100

accident, and providing perfect ventilation. The commutators are made of hard-drawn copper segments, insulated with mica, and mounted upon gunmetal sleeves, so that the commutator can be removed bodily from the dynamo spindle if necessary. The brushholders are of gunmetal, with the firms improved hold-off catch and tension regulator.



Combined Engine and Dynamo—End View.

The engines and dynamos are mounted upon combination bed-plates, and coupled together, as illustrated, a tachometer being provided so that the speed can be watched and regulated. The accompanying table gives details of the combined plants.

A NEW SYSTEM OF ELECTRICAL DISTRIBUTION AND TRANSMISSION.*

BY RANKIN KENNEDY.

The art of distributing electrical energy for general consumption over cities and towns is at the present time undergoing great developments, but cannot be said to have arrived at that stage at which electrical engineers can agree upon one system or common practice. Hence, in practice, we have many diverse systems. In some towns electrical energy is distributed by what is known as the low-pressure continuous-current system; in other towns the system is that known as the alternating-current high-pressure system; in some towns both systems are in use.

To-night I wish to bring before your notice a new system, which has been called the duplex system, in which the electrical energy is distributed by two currents alternating in different phases—a system which supplies electrical energy for electromotive power; for electric lighting, heating, electrotyping, and any other purposes for which electricity is used.

In any comprehensive scheme for distributing electrical energy for sale in towns or cities, the following conditions govern the supply: First, the supply to consumers must be absolutely safe; second, the supply should be available at all times, at any place in the city or town, and for any purpose to which electricity can be applied; third, the generating machinery and plant must be all together at one place, under one control; fourth, the supply should be available at the most distant districts of the city or town.

Now, in an electrical distribution works there are three departments: First, the generating department, comprising buildings, boilers, engines, dynamo-electric generators and regulators: here the electricity may be said to be manufactured out of the raw material—coal; second, the distributing department, comprising main conducting wires, and branch wires for carrying and distributing the electricity to the consumers; third, the consuming department, comprising electric lamps, electromotors, and other appliances in which the energy of the electricity is expended or converted. We need not enter into any general considerations concerning the generating department; but, regarding the distributing department, it may be explained that therein lies the difference between the various systems, and I shall here for a few minutes briefly touch upon the laws relating to conductors of electricity. The units in which electricity is measured are—the volt the unit of pressure, the ampere the unit of current, the ohm the unit of resistance. The number of amperes a wire of a given sectional area can carry is limited; the more amperes passed through a wire the more electrical energy is lost in heating the wire, and this loss rises rapidly as we increase the current, and it also rises directly as the length of the wire.

Now, although the amount of current which can be carried in any wire is limited, yet the electrical energy which any wire can carry is unlimited, except by practical difficulties in the way of perfect insulation. The energy conveyed by a wire is equal to the current, C, multiplied by the pressure, E, and insulation alone limits the pressure; hence, with a very small wire, a very great amount of electrical energy can be carried by a very small current if the pressure is made very high. The amount of energy carried by a current is equal to $E \times C = W$, or electrical energy. Now, suppose we have a wire of one tenth of a square inch in area, and one mile long, its resistance 0·5 ohms, to carry 100 amperes current; if we multiply the resistance of this wire by the current strength, $\cdot 5 \times 100 = 50$ volts, that gives us the pressure required to push the 100 amperes through this mile of wire—in fact, it is the difference of pressure between the two ends of the wire, a fall of 50 volts. The wire is joined to a generating dynamo at one end, and to 200 = 100-volt lamps at the other end half a mile away. Now, to get 100 volts at the lamps, we want ($100\text{ V} + 50 = 150$), 100 for the lamps, and 50 for one mile of wire, so that we see that one-third of the pressure is lost in the wire alone in this case. This example shows clearly the loss of pressure in long conductors, and how serious the loss is with low pressures, being a third of the whole pressure. But these are not all the difficulties in working at low pressures. Suppose there are consumers at different parts of the wire, some nearer the dynamo and some farther away, it is obvious they shall each get a supply at different pressures and at variable pressures. Now, allow me to take another [illegible] The pressure

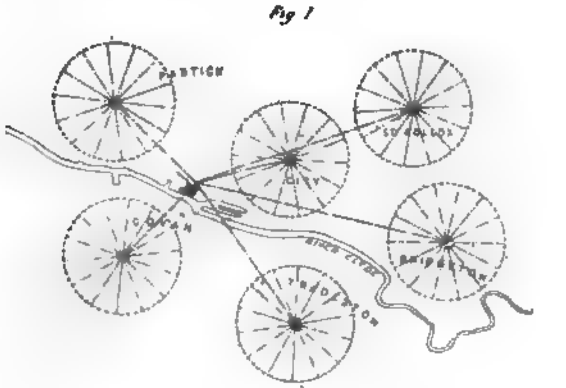
* Paper read before the Institution of Engineers and Shipbuilders in Scotland.

at the dynamo was 150 volts, at the lamps 100 volts; now, suppose we make the pressure at the dynamo 10 times greater, in this case we would have 1,500 volts pressure at the dynamo end. By keeping the current the same, 100 amperes, the loss of pressure in the wires would not be greater than it was when the dynamo pressure was only 150 volts—that is, it would still be 50 volts—we would therefore find 1,450 volts at the distant end. Now, 100 amperes at a pressure of 1,450 volts would give energy sufficient to supply 2,900 50-watt incandescent lamps, and the loss in transmission is now only 50 volts = 3 per cent. of the whole. To put the matter briefly, with low pressure of 150 volts we can transmit power for 200 lamps to half-mile distance with a loss of 30 per cent.; with a moderately high pressure of 1,500 volts we can transmit power for 2,900 lamps, half-mile distant, with a loss of only 3 per cent., using the same copper conductors in each case. If we work at low pressures, we must either have big losses in the wires or thick wires. These facts and figures are, I admit, quite schoolboy knowledge nowadays; but I wish to ground my

But the simple alternating-current systems do not entirely meet the requirements. A simple alternating current cannot be converted into continuous currents, for which there is always a demand, except by an expensive and difficult process. It cannot charge accumulators, and it has not hitherto been very successful in driving electro-motors.

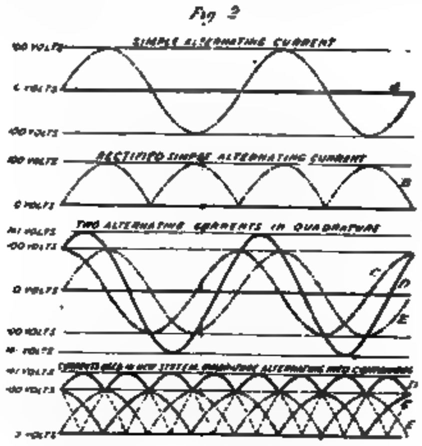
At the present moment the state of the art of electrical distribution is this. We know that at high pressures very great amounts of electrical energy can be transmitted over long distances with no serious losses. We know that alternating currents can be transformed from high to low pressure, or from low to high pressure, just as we require them. A continuous current cannot be so transformed without moving machinery of an objectionable nature; therefore the operations of continuous currents are confined to low-pressure work. The simple alternating-current systems now in use are quite satisfactory in so far as they supply electricity for lighting purposes only, but if only lighting can be successfully carried on by

Fig 1



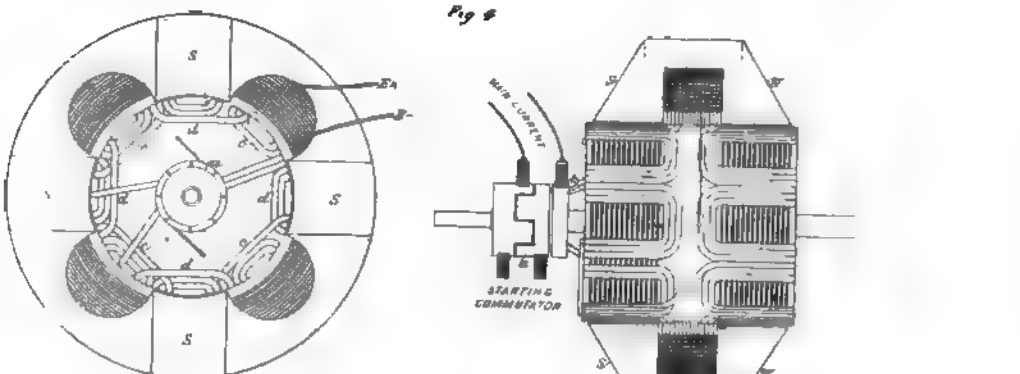
SYSTEM OF ELECTRICAL DISTRIBUTION

Fig 2



ALTERNATING CURRENT CURVES

Fig 4



SELF STARTING SYNCHRONISING MOTOR IRON CLAD FOR SIMPLE ALTERNATING CURRENT

arguments on the simplest facts, and these simple facts and figures govern the whole question of high *v.* low pressure electrical distribution.

Now, to save weight in the copper main conductors, it is obvious high pressures must be used; but for safety to the consumer and for working lamps in single parallel the pressure is restricted to 100 volts, so that if we use high pressure in the mains we must reduce the pressures before delivery to the consumer. This is a most important point, and on it turns the whole question—continuous *v.* alternating currents. The continuous-current systems are worked at a low pressure, for the simple reason that if at a high pressure it is a very difficult and expensive process to reduce to any other pressure; whereas with alternating currents the pressures can be cheaply, easily, and with certainty reduced, increased, or varied as you please. Hence alternating-current systems are always on the high-pressure system, and the high pressure is reduced to any other pressure by a simple apparatus called a transformer.

For these reasons the high-pressure alternating-current system has been adopted to a much larger extent, all over *the world, than the* low-pressure continuous-current system.

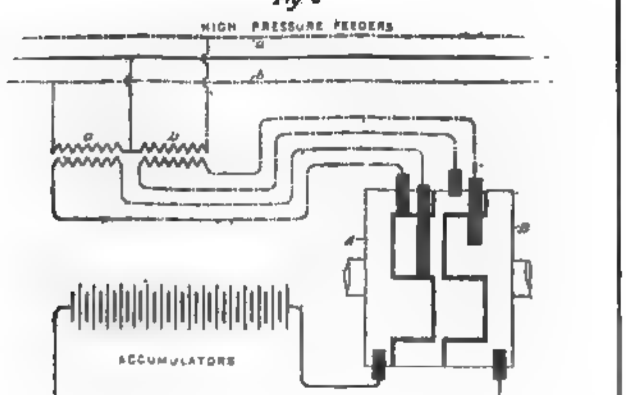
them, then it is obvious their sphere of usefulness is very limited. Electricity in continuous currents can be used for every purpose to which electricity can be applied, but it cannot easily be transformed in pressure. In this new system, which I shall endeavour to make clearly understood in this paper, the object is to combine the four essentials for a universally useful and extensive scheme of electrical distribution. The four essentials are: First, high pressure to carry the electricity long distances without losses; second, alternating currents easily and safely transformed; third, low pressure for distribution of electricity to consumers; fourth, continuous-current supply derived from the high-pressure distribution main wires.

These are the features of this new system. Referring to Fig. 1, a sketch map of Glasgow, the central or generating plant is supposed to be stationed down about Yorkhill. Sub-stations for the supply to the various districts of the city are marked off, as at Partick, City, St. Rollox, Bridgeton, Govan, and Tradeston. All these sub-stations draw their supplies of electricity through main wires at high pressure. The electricity is then reduced to low pressure, and distributed to consumer either as a com-

tinuous current or as an alternating current. The high-pressure feeders for the sub-stations are three wires carrying the electricity in two alternating currents. It is to be borne in mind that only these feeders are high pressure—on this system the sub-stations supply low pressure only, except to large consumers, these being treated as separate sub-stations.

Now, to enable us at the sub-stations to derive low-pressure alternating currents, or low-pressure continuous currents, from the high-pressure feeders, it is necessary to use two-phase alternating currents—currents differing in phase by a quarter of a period of alternation. These can be combined to form a simple alternating current, and they can be converted into a practically continuous current. The two currents are rectified into unidirection currents, and these can be used together or separately, either as one continuous current or one alternating current. Referring to Fig. 2, the curved lines show us the various types of alternating currents. A is a simple alternating current; B, same rectified; C E, two currents in quadrature; D, resultant line; C E, same rectified; D, resultant. The frequency of an alternating current is the number of ∼, complete waves, per second.

Fig. 3



The transformer for alternating currents is a very simple arrangement, which, besides converting the current from high to low pressure, effectually cuts off the consumers from all connection with the high-pressure system, as shown by experiment. The rectifying commutators are driven by a synchronising alternating-current motor, now before me, and which is shown in Fig. 4. N S, in sectional rear, is an iron-clad alternator, having all the N poles at one side and all the S poles at the other side, all excited by one coil. The armature has two circuits, connected to a starting commutator, *a*, with a ring contact, *b*, joined to the junction of the two armature circuits, *c*, *d*, respectively, with brushes as shown in the diagram. It is a reversed alternator. Now the starting up of synchronous motors has always been a difficulty. In this machine this difficulty has been met by using a commutator for starting up to synchronism. This commutator is then cut out of the circuit altogether. This motor has great power, is highly efficient, and governs perfectly; the commutator flashes somewhat at starting, but only for a few moments.

It may be here explained how the two alternating currents are got which are in use to-night. There are 30 E.P.S. accumulators downstairs; the continuous current from these is converted into two alternating currents in quadrature phase by means of an electromotor—which motor is a simple two-pole shunt-wound dynamo reversed. The alternating currents are collected from four rings on the motor shaft. Two of these rings are connected to diametrically opposite points of the commutator of the motor, and the other two are connected to two diametrically opposite points of the commutator at right angles to the first two. This arrangement converts the battery current into two alternating currents in quadrature. The highest frequency ∼ got by this arrangement is only about 18 per second; the E.M.F. is about 60 volts. Under these conditions the synchronous motor is sometimes a little difficult to start, as it was designed for a frequency of 80 ∼ per second, and 100 volts pressure. The transformer is simply an electromagnet, with two or more windings, and acts by induction. These transformers, C, D, in Fig. 3, receive the high-pressure alternating-currents at the sub-stations from high-pressure wires, and reduce it to low pressure—about 100 volts or thereby. The two currents are then passed through two rectifying commutators, which can be used for charging accumulators and other purposes, and thereby are converted into two unidirection pulsating currents, *a*, *b* (*see* Fig. 3). We shall now start the motor. On the end of the motor where the pulley should be placed, two commutators are fitted, such as are shown in Fig. 3, for the purpose of rectifying the two quadrature currents, and combining them into one continuous current. (Experiment made showing this continuous current driving a small continuous-current electromotor). We can by this means obtain continuous currents from the high-pressure supply of alternating currents sent out to the sub-stations.

(To be continued.)

NOTES ON THE LIGHT OF THE ELECTRIC ARC.*

BY ALEXANDER PELHAM TROTTER, B.A., MEMBER.

It is apparent to intelligent observers, and well known to all electric light engineers, that the light of an arc lamp is not emitted uniformly in all directions. Photometrical measurements of arcs are generally expressed by a polar curve, the length of the radius vector representing the candle-power. Although a good deal of work has been spent on this subject, the real meaning of the shape of these curves has not attracted much attention. They all exhibit the same characteristics, and it is easy to notice two distinct types of variation. One variation is found with arcs employing a large current, and consists in the emission of a small quantity of light in a direction above the horizon, the curve rising a little above the horizontal axis. Another type of variation is the narrowing of the whole curve, and the concentration of a large proportion of the light at an angle of about 40deg. or 50deg. with the vertical.

A rather complicated treatment of the subject has been made by M. Rousseau† with the object of finding a formula for the distribution of the light. His treatment appears to be empirical, and having arrived at a formula, he does not appear to have recognised the practical meaning which it contains.

It has been assumed by many persons that the hollowing of the crater of the positive carbon tends in some unexplained manner to concentrate and throw the light downwards. It is evident that the lower, or negative, carbon intercepts a good deal of the light; but there speculation appears to have stopped. A little consideration will show that the effect is precisely and identically the same as though the end of the positive carbon were flat. No tilting of an incandescent or other luminous surface can make it brighter; and, on the other hand, if it is covered with a thin, imperfectly transparent layer, as in the case of the atmosphere of the sun, the edge will appear less bright than the middle of the disc. The quantity of light emitted by an incandescent disc in any direction is proportional to the amount of surface visible from that direction. This is to say, candle-power varies, then, as the cosine of the inclination.

Cosines plotted as a polar curve give a circle passing through the pole. This theorem is not to be found in mathematical works, being much too easy and simple for those students who have got so far as polar curves. The candle-power of the crater of an arc lamp, should, then, if plotted as a polar curve, coincide with part of a circle. Any deviation from the circle must have some cause. Two such deviations are observed, and their causes are easily recognised.

An ideal continuous-current arc—in fact, any good one with first-rate carbons—has a uniform horizontal crater, and this gives no light in a horizontal direction, though a little may come from the hot sides of the carbon, especially if it is carrying a rather large current. No brightly incandescent surface is seen. The pointed negative carbon is seen in profile, and some light is emitted by it. From what Prof. S. P. Thompson and others have told us of the physics of the arc, it is very probable that the seat of the dissipation of energy is primarily at the surface of the crater. The negative carbon only becomes hot by being cooked in front of the crater. It is wasted, probably, by mere combustion; and even this waste is reduced by the deposition, under some circumstances, of carbon transferred from the positive pole. The waste of the positive carbon is undoubtedly due to volatilisation. Prof. J. J. Thomson and others have shown that electrolysis is not necessarily confined to bodies in the liquid state, and it seems probable that the volatilisation of carbon at the crater, and its deposition, under certain conditions, on the negative carbon, is closely allied to electrolysis, the positive pole behaving as an anode, both in its wasting and in the fall of volts

* Paper read before the Institution of Electrical Engineers.
† *La Lumière Electrique*, vol. xxxvii., p. 415.

at its surface. The absorption of energy appears to be twofold. A certain quantity of heat is required to produce the change of state from solid to vapour, and a certain difference of potential must be required to produce the electrolysis.

In one of the very interesting articles by M. Palaz* in which he abstracts and compiles the work of numerous continental writers, he states, without giving his authority, that 85 per cent. of the light of an arc is emitted by the positive carbon, 10 per cent. by the negative carbon, and 5 per cent. by the flame of the arc. It

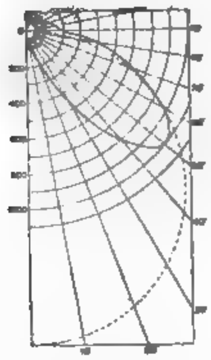


FIG. 1.

seems probable that in most cases the proportion of light emitted by the positive carbon is even greater than this. The word "arc" will be used in this paper as an abbreviation for arc lamp, and will not be used to denote the flame which plays between the carbons. The word "crater" will be used to denote that portion of the positive carbon which is at the highest degree of incandescence. This portion is generally well defined, the colour being uniform. The word "crater" will not be used to signify a hollowing of the carbon.

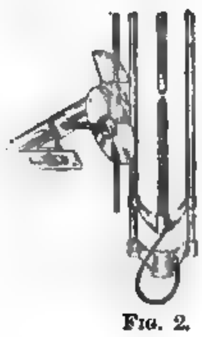


FIG. 2.

During the Antwerp Exhibition in 1885, M. Wybauw† made a number of photometric measurements of arcs by different makers. The full curve in Fig. 1 represents the mean of a large number of observations made, no less than 26 different arcs having been tested. The cosine of 60deg. being one-half, the area of the crater seen from this direction is one-half of that of the full circle; the candle-power is one-half of that emitted by the crater; and the length of the radius vector corresponding to 60deg. may be taken as the radius of the circle. The light due to the negative carbon is clearly shown as an excess above the circular curve; there is, indeed, nothing else to which it can be due, except the red-hot walls of the crater.

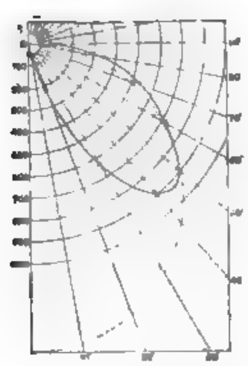


FIG. 3.

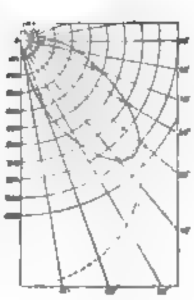


FIG. 4.

At about 60deg. the curve of candle-power begins to fall off, and this is due to nothing else than the shadow of the lower carbon which intercepts more and more of the light as we pass to smaller angles, until, if the carbons be of the same diameter, no light is thrown in a vertical direction.

In considering the real meaning of the latter part of the curve, the author drew a number of views of a pair of imaginary carbons, projected at different angles. The elliptical area of the crater in each view was calculated, and he found that these areas, plotted as radii of a polar curve, gave a curve closely resembling the well-known candle-power curve of the arc. It follows that, if this be proved to be true by experiment, the candle-power per square millimetre of the crater is constant. The author communicated this result to Prof. S. P. Thompson, and asked if he would see whether actual experiment would confirm it.

A series of very interesting experiments have been carried out at Finsbury Technical College by Mr. C. F. Higgins, senior student. A Planet lamp, taking eight or nine amperes, was first employed, and the first experiments showed that the light was undoubtedly proportional to the area of the crater. In order to carry out the experiments with greater accuracy, a larger lamp was required, and Messrs. Johnson and Phillips kindly lent a Brockie-Pell lamp, taking 25 amperes. The following apparatus, Fig. 2, was constructed by Mr. Higgins at the workshops of Finsbury College, for the purpose of projecting an image of the arc: An arm adjustable on a horizontal axis, and provided with a clamping nut and graduated arc, carries a lens and a mirror set at an angle of 45deg. with the direction of the ray of light falling on it, and reflecting the ray in a direction parallel with the axis of the radial arm. An image of the arc may thus be projected on a screen. As the radial arm is moved the image turns round,

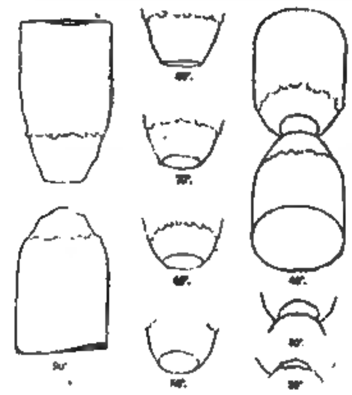


FIG. 5.

but this does not interfere with the observations. An Ayrton-Perry photometer, slightly modified, was used to measure the light with a standard candle, and this was done by removing the projecting lens, and allowing the reflected beam to fall on the mirror of the photometer. When the lens was replaced, for the purpose of projecting the image, the mirror of the photometer was removed, the rest of the photometer remaining undisturbed. The image was received on a sheet of drawing-paper, and was amplified about 14 times. The outline of the incandescent crater

FIG. 6.

was traced in pencil, and in some cases an outline of the carbons was drawn. The diameter of the carbons formed a standard for absolute measurements. Readings were taken at every 10deg. inclination. The area of the tracings was measured by a planimeter.

In the first experiments the absorption of the two mirrors was neglected, and the results are not, therefore, to be taken as candle-power. The mirror on the radial arm was of platinised glass, since an ordinary mirror gave a double image. The reflecting power was not good, though the image was clear. The areas were also measured to an arbitrary scale at first. Figs. 3 and 4 give polar curves of two sets of observations. The photometer readings are represented by circles, and the areas by triangles. A general coincidence of both sets of observations with the well-known curve is evident. Figs. 5 and 6 are reproductions of the tracings.

It is rather difficult in many cases to estimate the relation between two polar curves by mere inspection, partly, perhaps, because they are so seldom used in practice. Two different curves may be drawn, the one through the photometer readings, and the other through the areas of crater; but owing to the difficulty of arriving at accurate results on account of changes in the length of the arc, which greatly affect the inner part of the polar curve, and the occasional indistinctness of outline of the crater, the errors of either set of readings are probably as great as their departure from the curve drawn freely among the two sets.

Useful as it is to plot as a polar curve observations which relate to measurements taken at different angular directions, the relation between the two sets of readings may be examined more

* *La Lumière Electrique*, vol. xxxvii., p. 410.

† *La Lumière Electrique*, vol. xxxvii., p. 414, and vol. xxvi., p. 58.

easily when they are plotted with rectangular co-ordinates, Fig. 7. A straight line cutting the axis at 100 c.p. seems to fit the results. This may be explained by the light which is emitted by the red-hot and glowing parts of the carbon. These were not included in the measurement of area; the true crater only was measured. The author has been unable to carry out any complete experiments on the photometry of arcs; the present paper is only a collection of notes on the subject, which is treated qualitatively, and not quantitatively. The measurements, for various reasons, were relative, and attempts were made on one occasion only to take direct readings in candle-power. The image of the crater at 60deg. was projected and traced, and measured by a planimeter. The mean of several fairly concordant readings was 20·8 square inches. The diameter of the image of the carbon was 17in. Its actual diameter was 0·6in. The image was therefore magnified 28·3 times. The real area of the crater was 0·025 square inch. The candle-power readings were taken at the same angle, and immediately after the tracing of the image in each case, being measured directly from the arc without reflection. They were fairly concordant, and gave a mean of 1,065 candles. At the maximum position (about 45deg.) this would give about 1,400 candles. It follows, therefore, that the crater gave 42,600 c.p. per square inch, or 64 c.p. per square millimetre. The amperes were 26, and volts 51.

It is as impossible to raise carbon above the degree of incandescence of the crater of the arc as it is to raise water above boiling point or ice above melting point.* No substance has yet being suggested for "improving" arc lamp carbons which is less volatile than carbon. Even the core of cored carbons, while it serves a very useful purpose in steadying the arc, is less brilliant than the rest of the crater. If a lower temperature than the normal incandescence be found at the crater, it is because the positive carbon is too large for the current. Under these circumstances the arc generally flickers irregularly, and a highly incandescent patch travels about over the surface of the crater.

The large amount of light intercepted by the negative carbon raises the question, What becomes of it? It is evident that it strikes the lower carbon, and is probably converted into heat; but

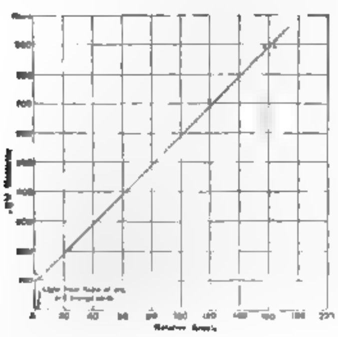


Fig. 7.

since only about 10 per cent. of the whole radiation of an arc is in the form of light,† most of the "cooking" of the lower carbon is done by mere heat.

It is not difficult to reconstruct the shape of the carbons which must have given rise to the curve given in Fig 1, but to do so is nothing more than a geometrical exercise, and leads to no useful result. A similar relation obtains between the candle-power curve of an alternating current arc and the shape of its carbons, but the use of alternating arcs is not common: the light is not, for outdoor purposes, thrown in a useful direction; it is difficult to prevent the arc from flickering round the carbons, and they give so much trouble from other causes that they are seldom worth using.

Two other kinds of arc are the lighthouse and the search-light. A very elaborate set of experiments was carried out in 1878 at Chatham, under the direction of the Royal Engineers Committee, by Major R. Y. Armstrong, Lieutenant G. Bowker, Lieutenant P. Cardew, Lieutenant L. Darwin, Lieutenant G. A. Carr, assisted by Lieutenant R. White and Captain Abney. Ten dynamos, six lamps, six projectors, and five kinds of carbons were tested; photometric measurements were made, and photographs were taken both facing the crater and at right angles to it. From the photographs the area of the crater could be determined. The candle-power per square inch seemed to vary in an indefinite way between 76,000 and 25,000 candles per square inch.

The photographs taken from the side give a very good idea of the position of the carbons and the small obstruction of the negative carbon when a search-light is properly arranged. Finding that so complete an examination of search-lights has been made, the author has not proceeded with the experiments which he had intended to carry out on this kind of lamp. He had some difficulty in finding this report, which was intended for Government use only. He was allowed by Major R. Ruck to examine a copy at the Horse Guards, and on making application through him to the Inspector-General of Fortifications the report was allowed to be made public. Instead of attempting to abstract this very interesting research, the author has presented the copy to the library of the Institution.

(To be continued.)

* S. P. Thompson, Society of Arts, March 6, 1889.

† Prof. Marks, American Inst. Electrical Engineers, vol. vi.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 405.)

When two wires, attached to the terminals of the coil, are set at the proper distance, the streams between them may be so intense as to produce a continuous luminous sheet. To show this phenomenon I have here two circles, C and c (Fig. 10), of rather stout wire, one being about 80 centimetres and the other 30 centimetres in diameter. To each of the terminals of the coil I attach one of the circles. The supporting wires are so bent that the circles may be placed on the same plane, coinciding as nearly as possible. When the light in the room is turned off and the coil set to work, you see the whole space between the wires uniformly filled with streams, forming a luminous disc, which could be seen from a considerable distance, such is the intensity of the streams. The outer circle could have been much larger than the present one; in fact, with this coil I have used much larger circles, and I have been able to produce a strongly luminous sheet, covering an area of more than one square metre, which is a remarkable effect with this very small coil. To avoid uncertainty, the circle has been taken

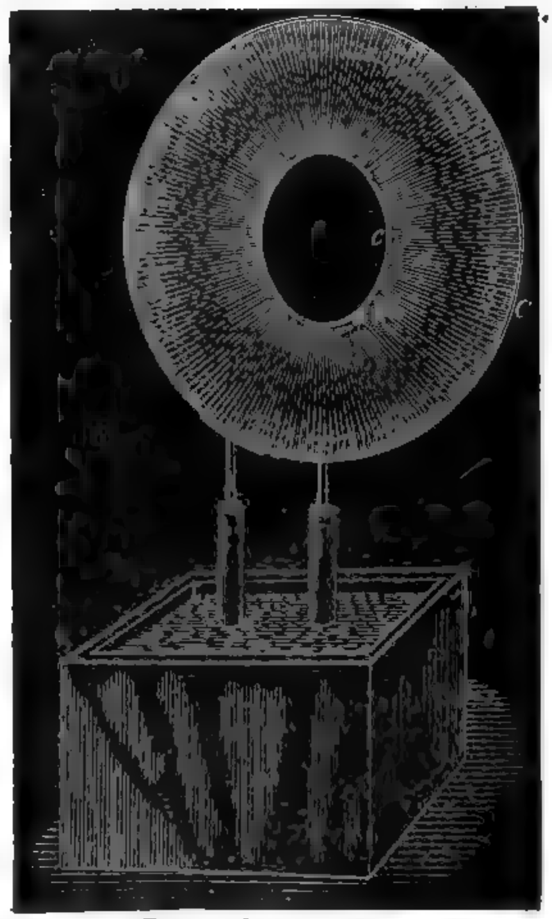


Fig. 10.—Luminous Discs.

smaller, and the area is now about 0·43 square metre. The frequency of the vibration and the quickness of succession of the sparks between the knobs affect to a marked degree the appearance of the streams. When the frequency is very low the air gives way in more or less the same manner as by a steady difference of potential, and the streams consists of distinct threads generally mingled with thin sparks, which probably correspond to the successive discharges occurring between the knobs. But when the frequency is extremely high, and the arc of the discharge produces a very loud but smooth sound—showing both that oscillation takes place and that the sparks succeed each other with great rapidity—then the luminous streams formed are perfectly uniform. To reach this result very small coils and jars of small capacity should be used. I take two tubes of thick Bohemian glass, about five centimetres in diameter and 20 centimetres long. In each of the tubes I slip a primary of very thick copper wire. On the top of each tube I wind a secondary of much thinner gutta-percha-covered wire. The two secondaries I connect in series, the primaries preferably in multiple arc. The tubes are then placed in a large glass vessel, at a distance of 10 to 15 centimetres from each other, on insulating supports, and the vessel is filled with boiled-out oil, the oil reaching about an inch above the tubes.

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

The free ends of the secondary are lifted out of the oil and placed parallel to each other at a distance of about 10 centimetres. The ends which are scraped should be dipped in the oil. Two four-pint jars joined in series may be used to discharge through the primary. When the necessary adjustments in the length and distance of the wires above the oil and in the arc of discharge are made, a luminous sheet is produced between the wires which is perfectly smooth and textureless, like the ordinary discharge through a moderately exhausted tube.

I have purposely dwelt upon this apparently insignificant experiment. In trials of this kind the experimentor arrives at the startling conclusion that to pass ordinary luminous discharges through gases no particular degree of exhaustion is needed, but that the gas may be at ordinary or even greater pressure. To accomplish this a very high frequency is essential; a high potential is likewise required, but this is a merely incidental necessity. These experiments teach us that in endeavouring to discover novel methods of producing light by the agitation of atoms, or molecules of a gas, we need not limit our research to the vacuum tube, but may look forward quite seriously to the possibility of obtaining the light effects without the use of any vessel whatever with air at ordinary pressure. Such discharges of very high frequency, which render luminous the air at ordinary pressures, we have probably often occasion to witness in nature. I have no doubt that if, as many believe, the aurora borealis is produced by sudden cosmic disturbances such as eruptions at the sun's surface, which set the electrostatic charge of the earth in an extremely rapid vibration, the red glow observed is not confined to the upper rarefied strata of the air, but the discharge traverses, by reason of its very high frequency, also the

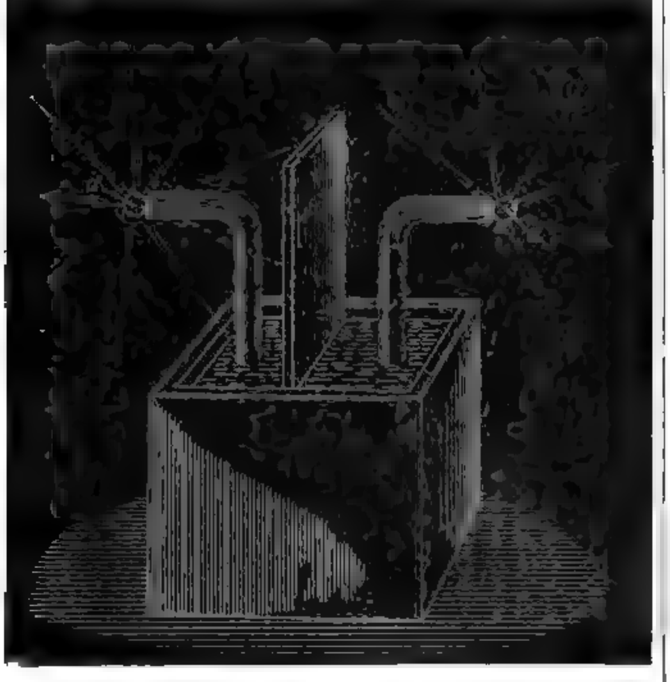


FIG. 11.—Phantom Streams.

dense atmosphere in the form of a glow, such as we ordinarily produce in a slightly exhausted tube. If the frequency were very low, or even more so, if the charge were not at all vibrating, the dense air would break down as in a lightning discharge. Indications of such breaking down of the lower dense strata of the air have been repeatedly observed at the occurrence of this marvellous phenomenon; but if it does occur, it can only be attributed to the fundamental disturbances, which are few in number, for the vibration produced by them would be far too rapid to allow a disruptive break. It is the original and irregular impulses which affect the instruments. The superimposed vibrations probably pass unnoticed. When an ordinary low frequency discharge is passed through moderately rarefied air, the air assumes a purplish hue. If by some means or other we increase the intensity of the molecular, or atomic, vibration, the gas changes to a white colour. A similar change occurs at ordinary pressures with electric impulses of very high frequency. If the molecules of the air around a wire are moderately agitated, the brush formed is reddish or violet; if the vibration is rendered sufficiently intense, the streams become white. We may accomplish this in various ways. In the experiment before shown with the two wires across the room, I have endeavoured to secure the result by pushing to a high value both the frequency and potential; in the experiment with the thin wires glued on the rubber plate, I have concentrated the action upon a very small surface—in other words, I have worked with a great electric density.

A most curious form of discharge is observed with such a coil when the frequency and potential are pushed to the extreme limit. To perform the experiment, every part of the coil should be heavily insulated, and only two small spheres—or better still, two sharp-edged metal discs (*d d*, Fig. 11) of no more than a few *centimetres* in diameter—should be exposed to the air. The coil here used is immersed in oil, and the ends of the secondary reaching out of the oil are covered with an air-tight cover of hard rubber of great thickness. All cracks, if there are any, should be carefully stopped up, so that the brush discharge cannot form anywhere except on the small spheres or plates which are exposed to the air. In this case, since there are no large plates or other bodies of capacity attached to the terminals, the coil is capable of an extremely rapid vibration. The potential may be raised by increasing, as far as the experimenter judges proper, the rate of change of the primary current. With a coil not widely differing from the present, it is best to connect the two primaries in multiple arc; but if the secondary should have a much greater number of turns, the primaries should preferably be used in series, as otherwise the vibration might be too fast for the secondary. It occurs under these conditions that misty white streams break forth from the edges of the disc and spread out phantomlike into space. With this coil, when fairly well produced, they are about 25 to 30 centimetres long. When the hand is held against them, no sensation is produced, and a spark, causing a shock, jumps from the terminal only upon the hand being brought much nearer. If the oscillation of the primary current is rendered intermittent by some means or other, there is a corresponding throbbing of the streams, and now the hand or other conducting object may be brought in still greater proximity to the terminal without a spark being caused to jump. Among the many beautiful phenomena which may be produced with such a coil, I have here selected only those which appear to possess some features of novelty, and lead us to some conclusions of interest. One will not find it at all difficult to produce in the laboratory by means of it many other phenomena which appeal to the eye even more than those here shown, but present no particular feature of novelty.

Early experimenters describe the display of sparks produced by an ordinary large induction coil upon an insulating plate separating the terminals. Quite recently Siemens performed some experiments in which fine effects were obtained, which were seen by many with interest. No doubt large coils, even if operated with currents of low frequencies, are capable of producing beautiful effects. But the largest coil ever made could not, by far, equal the magnificent display of streams and sparks obtained from such a disruptive discharge coil when properly adjusted. To give an idea, a coil such as the present one will cover easily a plate of one metre in diameter completely with the streams. The best way to perform such experiments is to take a very thin rubber or a glass plate and glue on one side of it a narrow ring of tinfoil of very large diameter, and on the other a circular washer, the centre of the latter coinciding with that of the ring, and the surfaces of both being preferably equal, so as to keep the coil well balanced. The washer and ring should be connected to the terminals by heavily insulated thin wires. It is easy in observing the effect of the capacity to produce a sheet of uniform streams, or a fine network of thin silvery threads, or a mass of loud brilliant sparks, which cover completely the plate.

Since I have advanced the idea of the conversion by means of the disruptive discharge, in my paper before the American Institute of Electrical Engineers at the beginning of the past year, the interest excited in it has been considerable. It affords us a means for producing any potentials by the aid of inexpensive coils operated from ordinary systems of distribution, and—what is perhaps more appreciated—it enables us to convert currents of any frequency into currents of any other lower or higher frequency. But its chief value will perhaps be found in the help which it will afford us in the investigations of the phenomena of phosphorescence, which a disruptive discharge coil is capable of exciting in innumerable cases where ordinary coils, even the largest, would utterly fail. Considering its probable uses for many practical purposes, and its possible introduction into laboratories for scientific research, a few additional remarks as to the construction of such a coil will, perhaps, not be found superfluous. It is, of course, absolutely necessary to employ in such a coil wires provided with the best insulation. Good coils may be produced by employing wires covered with several layers of cotton, boiling the coil a long time in pure wax, and cooling under moderate pressure. The advantage of such a coil is that it can be easily handled, but it cannot probably give as satisfactory results as a coil immersed in pure oil. Besides, it seems that the presence of a large body of wax affects the coil disadvantageously, whereas this does not seem to be the case with oil. Perhaps it is because the dielectric losses in the liquid are smaller. I have tried at first silk-covered and cotton-covered wires with oil immersion, but I have been gradually led to use guttapercha-covered wires, which proved most satisfactory. Guttapercha insulation adds, of course, to the capacity of the coil, and this, especially if the coil be large, is a great disadvantage when extreme frequencies are desired; but, on the other hand, guttapercha will withstand much more than an equal thickness of oil, and this advantage should be secured at any price. Once the coil has been immersed, it should never be taken out of the oil for more than a few hours, else the guttapercha will crack up and the coil will not be worth half as much as before. Guttapercha is probably slowly attacked by the oil, but after an immersion of eight to nine months I have found no ill-effects. I have obtained in commerce two kinds of guttapercha wire: in one the insulation sticks tightly to the metal, in the other it does not. Unless a special method is followed to expel all air, it is much safer to use the first kind. I wind the coil within an oil tank so that all interstices are filled up with the oil. Between the layers I use cloth boiled out thoroughly in oil, calculating the thickness according to the difference of potential between the turns. There seems not to be a very great difference whatever kind of oil is used; I use paraffin or linseed oil.

To exclude more perfectly the air, an excellent way to proceed, and easily practicable with small coils, is the following: Construct a box of hard wood of very thick boards which have been for a long time boiled in oil. The boards should be so joined as to safely withstand the external air pressure. The coil being placed and fastened in position within the box, the latter is closed with a strong lid, and covered with closely-fitting metal sheet, the joints of which are soldered very carefully. On the top two small holes are drilled, passing through the metal sheet and the wood, and in these holes two small glass tubes are inserted and the joints made air-tight. One of the tubes is connected to a vacuum pump, and the other with a vessel containing a sufficient quantity of boiled-out oil. The latter tube has a very small hole at the bottom, and is provided with a stop-cock. When a fairly good vacuum has been obtained, the stop-cock is opened and the oil slowly fed in. Proceeding in this manner, it is impossible that any big bubbles, which are the principal danger, should remain between the turns. The air is most completely excluded, probably better than by boiling out, which, however, when guttapercha-coated wires are used, is not practicable. For the primaries I use ordinary line wire with a thick cotton coating. Strands of very thin insulated wires properly interlaced would, of course, be the best to employ for the primaries, but they are not to be had. In an experimental coil the size of the wires is not of great importance. In the coil here used the primary is No. 12, and the secondary No. 24 Brown and Sharpe W.G. wire; but the sections may be varied considerably; it would only imply different adjustments, the results aimed at would not be materially affected.

I have dwelt at some length upon the various forms of brush discharge because, in studying them, we not only observe phenomena which please our eye, but also afford us food for thought, and lead us to conclusions of practical importance. In the use of alternating currents of very high tension, not too much precaution can be taken to prevent the brush discharge. In a main conveying such currents, in an induction coil or transformer, or in a condenser, the brush discharge is a source of great danger to the insulation. In a condenser especially the gaseous matter must be most carefully expelled, for in it the charged surfaces are near each other, and if the potentials are high, just as sure as a weight will fall if let go, so the insulation will give way if a single gaseous bubble of some size be present, whereas, if all gaseous matter were carefully excluded, the condenser would safely withstand a much higher difference of potential. A main conveying alternating currents of very high tension may be injured merely by a blow-hole or small crack in the insulation, the more so as a blow-hole is apt to contain gas at low pressure; and as it appears almost impossible to completely obviate such little imperfections, I am led to believe that in our future distributions of electrical energy by currents of very high tension, liquid insulation will be used. The cost is a great drawback, but if we employ an oil as an insulator, the distributions of electrical energy with something like 100,000 volts, and even more, become, at least with higher frequencies, so easy that they could be hardly called engineering feats. With oil insulation and alternate-current motors transmissions of power can be effected with safety, and upon an industrial basis, at distances of as much as a thousand miles.

A peculiar property of oils, and liquid insulation in general, when subjected to rapidly changing electric stresses, is to disperse any gaseous bubbles which may be present, and diffuse them through its mass, generally long before any injurious break can occur. This feature may be easily observed with an ordinary induction coil by taking the primary out, plugging up the end of the tube upon which the secondary is wound, and filling it with some fairly transparent insulator, such as paraffin oil. A primary of a diameter something like six millimetres smaller than the inside of the tube may be inserted in the oil. When the coil is set to work, one may see, looking from the top through the oil, many luminous points—air bubbles which are caught by inserting the primary, and which are rendered luminous in consequence of the violent bombardment. The occluded air, by its impact against the oil, heats it; the oil begins to circulate, carrying some of the air along with it, until the bubbles are dispersed and the luminous points disappear. In this manner, unless large bubbles are occluded in such way that circulation is rendered impossible, a damaging break is averted, the only effect being a moderate warming up of the oil. If, instead of the liquid, a solid insulation, no matter how thick, were used, a breaking through and injury of the apparatus would be inevitable.

The exclusion of gaseous matter from any apparatus in which the dielectric is subjected to more or less rapidly changing electric forces is, however, not only desirable in order to avoid a possible injury of the apparatus, but also on account of economy. In a condenser, for instance, as long as only a solid or only a liquid dielectric is used, the loss is small; but if a gas under ordinary or small pressure be present the loss may be very great. Whatever the nature of the force acting in the dielectric may be, it seems that in a solid or liquid the molecular displacement produced by the force is small: hence the product of force and displacement is insignificant, unless the force be very great; but in a gas the displacement, and therefore this product, is considerable; the molecules are free to move, they reach high speeds, and the energy of their impact is lost in heat or otherwise. If the gas be strongly compressed, the displacement due to the force is made smaller, and the losses are reduced.

In most of the succeeding experiments I prefer, chiefly on account of the regular and positive action, to employ the alternator before referred to. This is one of the several machines constructed by me for the purposes of these investigations. It has 384 pole projections, and is capable of giving currents of a frequency of about 10,000 per second. This machine has been illustrated and briefly described in my first paper before the American Institute of Electrical Engineers, May 20th, 1891, to which I have already referred. A more detailed description, sufficient to enable any engineer to build a similar machine, will be found in several electrical journals of that period. The induction coils operated from the machine are rather small, containing from 5,000 to 15,000 turns in the secondary. They are immersed in boiled-out linseed oil, contained in wooden boxes covered with zinc sheet. I have found it advantageous to reverse the usual position of the wires, and to wind, in these coils, the primaries on the top; this allowing the use of a much bigger primary, which, of course, reduces the danger of overheating, and increases the output of the coil. I make the primary on each side at least one centimetre shorter than the secondary, to prevent the breaking through on the ends, which would surely occur unless the insulation on the top of the secondary be very thick, and this, of course, would be disadvantageous. When the primary is made movable, which is necessary in some experiments, and many times convenient for the purposes of adjustment, I cover the secondary with wax, and turn it off in a lathe to a diameter slightly smaller than the inside of the primary coil. The latter I provide with a handle reaching out of the oil, which serves to shift it in any position along the secondary.

I will now venture to make, in regard to the general manipulation of induction coils, a few observations bearing upon points which have not been fully appreciated in earlier experiments with such coils, and are even now often overlooked. The secondary of the coil possesses usually such a high self-induction that the current through the wire is inappreciable, and may be so even when the terminals are joined by a conductor of small resistance. If capacity is added to the terminals, the self-induction is counteracted, and a stronger current is made to flow through the secondary, though its terminals are insulated from each other. To one entirely unacquainted with the properties of alternating currents nothing will look more puzzling. This feature was illustrated in the experiment performed at the beginning with the top plates of wire gauze attached to the terminals and the rubber plate. When the plates of wire gauze were close together, and a small arc passed between them, the arc prevented a strong current to pass through the secondary, because it did away with the capacity on the terminals; when the rubber plate was inserted between, the capacity of the condenser formed counteracted the self-induction of the secondary, a stronger current passed now, the coil performed more work, and the discharge was by far more powerful. The first thing, then, in operating the induction coil is to combine capacity with the secondary. to overcome the self-induction. If the frequency and potentials are very high, gaseous matter should be carefully kept away from the charged surfaces. If Leyden jars are used, they should be immersed in oil, as otherwise considerable dissipation may occur if the jars are greatly strained. When high frequencies are used, it is of equal importance to combine a condenser with the primary. One may use a condenser connected to the ends of the primary or to the terminals of the alternator, but the latter is not to be recommended, as the machine might be injured. The best way is, undoubtedly, to use the condenser in series with the primary and with the alternator, and to adjust its capacity so as to annul the self-induction of both the latter. The condenser should be adjustable by very small steps, and for a finer adjustment a small oil condenser with movable plates may be used conveniently.

(To be continued.)

INSTITUTION OF CIVIL ENGINEERS.

ELECTRICAL MEASURING INSTRUMENTS.

At the ordinary meeting on Tuesday, the 26th of April, when the chair was occupied by the president, Mr. George Berkley, the paper read was on "**Electrical Measuring Instruments,**" by **Mr. James Swinburne.**

The rapid development of electric lighting had called into existence a number of measuring instruments designed expressly for the use of electrical engineers. This paper consisted, mainly, of a critical description of these instruments.

Although voltmeters and ampere-meters generally differed in their windings only, it was advisable to design voltmeters to read clearly over a small part of their scale, while ampere-meters should be equally legible throughout the whole of their ranges. All voltmeters and ampere-meters should be direct-reading; turning milled heads and coefficients were not admissible in modern electric light instruments. Voltmeters should absorb as little power as possible, as every watt taken was equal to the interest on £1. Horizontal dials and suspension fibres or compass-points were to be avoided. The simplest soft-iron instruments contained a small needle inside a coil. The needle tended to arrange itself in the axis of the coil, the torque being opposed by gravity or springs. Instruments of this type had been made by Miller, Crompton, Statter, Lord Kelvin, and others. In Cunynghame's form the solenoid had an iron core. In the Schuckert, Walsall, Evershed, and Hartmann and Braun instruments, the soft-iron needle moved laterally into a stronger field, the field being modified by suitable fixed iron cores. The attraction of a solenoid upon a small soft-iron core was utilised in volt and ampere meters by Lord Kelvin, Kohlrausch, and Dolivo-Dobrowolsky, and Ayrton and Perry. The inventors last named employed their twisted

strip to give large readings. Messrs. Crompton and Kapp in England, and Elihu Thomson in America, had made instruments whose readings depended on the relative intensity of field produced by solenoids with and without iron cores.

Permanent magnets fell into undeserved disrepute a few years ago; but it was now more generally realised that they could be safely employed in instruments of the highest class. Carpentier and Ayrton and Perry used permanent magnets for providing a constant controlling field in 1881, but Lord Kelvin's lamp-counter was one of the few survivors of this class. Instruments with permanent needles were made by Paterson and Cooper, Latimer Clark, Muirhead, and Co., and Siemens. The moving coil was used in Weston's instruments alone, though the Deprez-D'Arsonval galvanometer might also be called an electric light instrument. The Weber dynamometer survived in the Siemens dynamometer and in Lord Kelvin's balances. The Cardew and one form of the Ayrton and Perry instrument depended on the expansion of a fine platinum iridium wire heated by the current to be measured.

Electrostatic voltmeters were made by Lord Kelvin and Swinburne and Co.

The meter was by far the most important instrument, as the whole profit or loss of a station depended on its accuracy. The accuracy of a meter, within 1 per cent. or so, should be guaranteed, as a very small error made a large variation in the profits of a station. The chief faults in commercial meters, besides inaccuracy, were: (1) Not starting until a large load was on; (2) absorbing power in shunt circuits; (3) absorbing power in the main circuit and reducing the light of the lamps; (4) getting out of order through the use of mercury; (5) needing frequent winding up; (6) wearing out through rapid movement of working parts; (7) stopping on account of insects or damp; (8) costliness.

Chemical meters have been used by Edison abroad, and by Wright in this country.

The majority of meters consisted of motors driving brakes of various kinds. The laws governing the brakes commonly used were not very well understood, and some forms of motor-meter appeared to be inaccurate. Faure first used one-turn motor-meters, and he had been followed by Ferranti, Edison, Borel, Miller, Teague, Perry, Weston, Hookham, Hartmann and Braun, and many others. The Ferranti meter for direct currents had a permanent field and an armature in the main circuit. Fluid friction regulated the speed. The Hookham meter had a permanent field magnet and an armature of several turns with a double commutator dipping into mercury, and a Foucault-current brake. The Hartmann and Braun had a one-turn armature, arranged as in Faraday's disc experiment. The Perry meter had a one-turn, or disc armature, completely submerged in mercury, and a very efficient Foucault-current brake. Joule meters, or wattmeters as they were often called, had the disadvantage of wasting power, and this might outweigh any benefits due to extra accuracy. In the Thomson-Houston meter the field was produced by coils in the main circuit, while the armature of high resistance was in shunt. Magnetic Foucault-current brakes were employed. The Hummel meter was on the same principle, but had an electromagnetic brake which converted it into a coulomb-meter. The Shallenberger alternating-current meter had a small double-current motor, the rotation of which was retarded by an air-brake. The Wright meter depended on a different form of alternating-current motor. The Ayrton and Perry clock meter had been put into commercial shape by Aron, and was one of the most successful types. Two clocks were connected by differential gear. One was made to keep bad time, gaining or losing according to the current. The differential gear registered the difference caused.

A numerous class of meter consisted of a wattmeter or amperemeter with a clock and feeling mechanism. The various mechanical methods of carrying out this idea were numberless, and did not need separate description. Meters of this class had been brought out by the Brush Company, Brillié, Cauderay, Fraser, Hartmann and Braun, Lord Kelvin, Siemens, and many others.

The only form of heat-engine meter that had been developed was that due to Forbes. The main current heated a small coil of wire, and the draught of hot air produced rotated a small propeller windmill, and this worked the index train.

The discussion upon the above communication was commenced, and it was stated that it would be continued on Tuesday, May 3—when, in consequence of other arrangements, it must be concluded, and when there will be a ballot for three members, 29 associate members, and one associate.

The remaining ordinary meetings on May 10, 17, and 24 will be occupied with the reading and discussion of papers on "The Distribution and Measurement of Illumination," by Mr. Alex. P. Trotter, and on "The Measurement of High Temperatures," by Prof. W. C. Roberts-Austen. The annual general meeting will fall this year on Tuesday, the 31st of May, when the report of the council on the state of the institution will be presented, and the election of the council and officers for the ensuing year will take place.

Manchester.—Messrs. Maunsell, Mercier, and Co., electrical, gas, and sanitary engineers, having been appointed district representatives of the Wenham Company, Limited, electrical, gas, and ventilating engineers, of London, have taken the premises at 5, Deansgate, Manchester, lately occupied as the Manchester depôt of that firm. Messrs. Maunsell, Mercier, and Co. have also taken over the gas, sanitary, and colliery stores departments of the late firm of *Mercier, Corlett, and Co.*, of Wigan and Bolton.

LEGAL INTELLIGENCE.

ENGLISH AND SCOTTISH INVESTMENT COMPANY v. BRUNTON.

The Fire at West Drayton.

This case, which involved some difficult and intricate points, was argued some time since before Mr. Justice Charles, when judgment was reserved.

Mr. R. T. Reid, Q.C., Mr. Tyrrell T. Paine, and Mr. Sargent appeared for the plaintiffs; Mr. A. Cohen, Q.C., Mr. Bremner, and Mr. Le Fanu were counsel for the defendant.

Judgment was given in this case on Tuesday last. It ought to be stated that it was really a question in connection with the Electrical Engineering Corporation, which carried on business in premises at West Drayton. Our readers will recollect that in 1891 a fire occurred on these premises, and as they were insured, the insurance office had a certain amount to pay. The company, which already had a debenture issue of a stringent character, borrowed money on account of the amount to be so paid. The debenture holders claimed that the insurance should come to them, while the lenders of the money upon special security claimed it.

Mr. Justice Charles gave judgment in favour of the lenders of the money.

COMPANIES' MEETINGS.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY, LIMITED.

The first annual ordinary general meeting of the shareholders of this Company was held on Friday last at Winchester House, Old Broad-street, Sir Richard J. Meade, K.C.S.I. (the chairman), presiding.

The **Secretary** (Mr. J. Shurmur) read the notice convening the meeting and the report was taken as read.

The **Chairman** said: Gentlemen, I am sorry to say that I am compelled to ask your forbearance this morning, as, having a bad cold, my voice is so broken that I really cannot depend on speaking for five minutes together, so that I propose to ask the deputy chairman of the Company, Major Jones, to read to you the remarks which I have drawn up for submission to-day. I will only say that Major Jones is a gentleman who was for many years employed in one of the most responsible departments under Messrs. Armstrong, and that he has a special knowledge of manufactures of every description.

Major Charles Jones then read the Chairman's speech as follows: Gentlemen,—I have much pleasure in appearing before you to-day to give you the results of our stewardship up to the end of December last, and to congratulate you on the result and future prospects of the policy which was inaugurated by your Directors, and approved by you, at the statutory general meeting—viz., that having satisfied ourselves as to the quality of the products made by the Elmore process, and the facility with which the same could be manufactured, we should follow no hesitating policy, but at once take the bold step of laying out our works on a scale commensurate with the importance of the industry. I am pleased to be able to state to you the success that this policy has attained. To-day we are in the unique position of having magnificent works already started—second to none in the world for the manufacture of this class of product complete and capable of turning out 300 tons a month, whilst with comparatively little outlay, and in a short space of time, we should be able to nearly double this output. Had it not been for the broad policy so strongly urged by M. Secrétan, who would not accept the general managership of the Company in France unless the works were commenced on what he calls a small, but what we call a large scale—viz., for an output of 300 tons a month. Had it not been for M. Secrétan's assurance that he was abundantly satisfied that the quality, cost, and facility of manufacture of articles under the Elmore process would turn out what he is now able to prove, we should not, at so early a stage, have taken the responsibility—which, I may say, gentlemen, has until recently been a very great responsibility—viz., that of embarking your money in so large a factory, until we had actually been at work on a commercial scale. The responsibility we have undertaken is, however, amply compensated for by the satisfaction that we feel to-day in the successful carrying out of our policy. With regard to the accounts submitted with the Directors' report, which is in your hands, these duly deal with capital expenditure, and there is little to say in reference to them, as they explain themselves. Some of the items will not appear in future years, whilst with regard to the administration charges, these have naturally been heavy, as they include all charges under this head in connection with the erection of the works, which will not occur again. The expenditure in the experimental workshop at Paris has been most usefully applied to the training of engineers and workmen in the Elmore process while the factory was being erected, so as to ensure their being fit for their duties on its completion, and also to the working out all special requirements of the French trade, which has enabled us to deliver the goods in demand directly we commenced manufacturing. With regard to the proposed increase of capital, your Directors recommend that such increase shall consist of 100,000 shares of £2 each, of which 60,000 shall be now issued as preference shares entitled to 10 per cent. dividend. The terms of this new issue will give to

existing shareholders the right to subscribe for two-thirds of the amount, if they desire to do so. Shareholders who may wish for a larger allotment than they would be entitled to under the proportion this would allow them—viz., two shares for every five they now hold—can apply for a larger number. Some of our shareholders, whilst congratulating us upon our position, seem to have misunderstood our proposal. I may therefore state that it is true that no more than 60,000 preference shares should now be issued, and that no further capital should be issued until we have proved by the actual earning of profits that the employment of this capital is advisable. You may be sure that your Directors would not issue this capital unless its employment would increase the dividends that you were going to receive; and possibly, when we come to issue the capital, we may be able to issue it on considerably better terms than those now offered. We have been criticised by some who say that the terms for the preference shareholders are far too good. All that we say to this is, that, with the exception of a small amount of capital which we consider it advisable to issue to those outside the body of shareholders, we shall allot to each shareholder his exact proportion, and at the same time, those who would be desirous of having a larger allotment can apply, and their applications will be dealt with together with applications from the general public; you may be sure that we shall well look after the interests of those shareholders who may so apply. M. Secrétan shows that the additional profit that would result from the employment of such further capital would be very large, and out of all proportion to the additional outlay. His estimates are based on experience; but it should be explained that they mostly represent the profits to be made on the cheapest articles of everyday consumption. It has been deemed advisable, in order to meet the demands of the market, to be able to supply every variety of article needed, and to turn our attention, in the first instance, to these cheaper productions. A large part of the new capital will be devoted to the production of more valuable goods, from which larger profits will be obtained. I should add that the cost of production will be reduced, as the standing charges will not be materially increased, and the additions to the existing engine power will be comparatively small. I will not detain the meeting by further remarks, and will only add that we shall be happy to give any further information that may be required by any member present. I will now conclude by moving the following resolution: "That the Directors' report and balance sheet for the period commencing from the date of the Company's formation—viz., September 10, 1890, to December 31, 1891—now submitted to the meeting, be, and are, approved and adopted."

M. Secretan, who spoke in French, said that in the last report issued to the shareholders on the 1st of April he had given them his opinion, and had nothing to take from it. They were at present producing about eight or nine tons per week, but in a fortnight or three weeks they would be doing considerably more. There had, of course, been some unavoidable delay in getting to work—in a great measure covered by the fact that to obtain orders in France it was necessary to supply all kinds of goods, as French men would not divide their orders.

Major Jones seconded the adoption of the report, and expressed his personal confidence, as an expert, in the Elmore process.

In reply to a question as to what the English was doing, **Mr. Elmore** pointed out that the success of the French Company might be gauged by the fact that the English Company was at the present time doing business at a profit equal to a dividend of 40 per cent. on the total capital.

Mr F. L. Rawson pointed out that it was essential that further capital should be provided, as whenever they were dealing with a patent, it was desirable to increase the output to the fullest extent. They must remember that they had only 13 years in which they could expect to make these very large profits.

After some further discussion the report was agreed to unanimously.

The usual formal elections having been carried,

A resolution was passed, increasing the capital of the Company to £400,000 by the creation of £100,000 new shares of £2 each, such shares to be preference shares, with a preferential dividend of 10 per cent., and entitled to a further dividend of 5 per cent. after 15 per cent. was paid upon the existing shares.

INDO-EUROPEAN TELEGRAPH COMPANY, LIMITED.

The twenty fifth ordinary general meeting of this Company was held on Wednesday at Winchester House, Old Broad-street, Mr. J. Herbert Tritton presiding.

The **Chairman** observed that the past year had been on the whole favourable for the Company. Their receipts were increased by £2,891, and the number of words exchanged with India for the first time exceeded by 40,390 the number of words exchanged before the reduction in the rates which was applied in 1886, although as yet the money earned was still less by £39,521 than it would have been, with a similar traffic, had not the rate been reduced. The expenses were £57,902 on all accounts, and they were able to place £10,000 to the reserve fund and to recommend the payment of a dividend which, with the interim distribution, made 10 per cent. for the year. They would carry forward £5,983, as against £1,168 last year. At their last meeting he expressed his personal opinion that the 12 months' trial then proposed of the reduced rates with Australia was not sufficient. This had proved to be the case. They had not yet received accounts for one clear year's traffic, and it had been determined by all the parties to the agreement not to give the required notice of termination, and consequently the agreement would remain in force. They had thought it well to contribute on behalf of the Company towards the relief of the sufferers by the Russian famine the sum of £500. With Persia there had been increased telegraphic intercourse, by which they had benefited, and on the whole, taking the complete range of the business, there was an improvement in the Company's affairs. He concluded by proposing the adoption of the report.

Mr. E. Weaver seconded the motion, which was adopted.

ORIENTAL TELEPHONE COMPANY, LIMITED.

The twelfth ordinary annual general meeting of this Company was held on Wednesday, at The City Terminus Hotel.

Mr. William Addison, who presided, said that owing to the low price of silver and consequent depreciation in exchange, their net profits had not materially increased. The decision of the Court as to the manner of declaration and distribution of dividend was in favour of the Directors' action, but since the issue of the report the Directors had received notice of appeal against the decision of Mr. Justice Kekewich, and the meeting would understand that he could not now make any remarks upon the case. They proposed to add £3,000 to the reserve fund, bringing it up to £10,000. It had been the endeavour of the Board to accomplish two things—the one to arrange terms with the holders of the vendors' shares on a reasonable and equitable basis, and the other to abolish or greatly reduce the liability of 9s. on the ordinary shares upon which 11s. was paid—and they were in hopes of arriving at a satisfactory settlement. The Telephone Company of Egypt was still progressing and paid its 6 per cent. on the preferred shares, the whole of which the Oriental Telephone Company practically held. All the exchanges worked by the Company were kept in a state of efficiency. He concluded by moving the adoption of the report and accounts and the declaration of a dividend, tax free, at the rate of 2½ per cent.

Mr B. St John Ackers seconded the motion which was carried.

At the conclusion of the ordinary business, the following resolution was agreed to: "That the name of the Company be changed to 'The Oriental Telephone and Electric Company, Limited.'"

NEW COMPANIES REGISTERED.

Madras Electric Tramways Company, Limited.—This Company has been formed, with a capital of £100,000 in £1 shares, for the purpose of acquiring a concession granted by the municipal authorities of Madras, by an order bearing date November 18, 1891, and approved by the Madras Government, for the construction and working of tramways in Madras. The tramway lines are divided into six sections, with a mileage of 15¼ miles, or including sidings, 18 miles. The prospectus states that the Directors hold estimates from firms of the highest character in the United Kingdom which enable them to state that the lines will be laid, buildings erected, and plant provided for a sum not exceeding £5,000 per mile. The motive power to be employed is electricity, conveyed by overhead wires from a central station. The Directors anticipate that not more than half the share capital will be called up.

South American Cable Company.—This Company has been formed, with a share capital of £500,000 in £10 shares, to complete an additional telegraphic route between Europe and South America by the laying of cables, under concessions from the Brazilian and French Governments, between Pernambuco in Brazil and St. Louis in Senegal, touching at the island of Fernando de Noronha. An agreement has been entered into with the India Rubber, Gutta Percha, and Telegraph Works, Company, Limited, to make and lay suitable cables, and to supply the necessary working and testing instruments for the cable stations, and to hand over to this Company the Brazilian concession for the sum of £520,000, of which they have agreed to take £100,000 in fully-paid shares. The whole of the cables have been manufactured and shipped, and it is expected that the laying will be completed by the middle of July. The Senegal end of the cable is already laid. The present issue is of 30,000 £10 shares, of which 10,000 will be taken by the contractors, and 20,000 are offered for subscription; £300,000 of 5 per cent. mortgage debentures of £100 each are also offered for subscription at £94 per cent.

BUSINESS NOTES.

Oriental Telephone Company. This Company is to be known henceforth as "The Oriental Telephone and Electric Company, Limited."

Sanitary and Electrical.—Messrs. A. B. Gill and Co. send us a notice to the effect they are undertaking sanitary inspection as part of their sanitary, electrical, and mechanical engineering business.

Tubes.—Mr. John Spencer, of the Globe Tube Works, Wednesbury, informs us that he has increased his discounts from tubes and fittings 2½ per cent. on the gross; iron and steel boiler tubes remain as before.

Western and Brazilian Telegraph Company, Limited.—The traffic receipts of this Company for the week ending April 22, after deducting 17 per cent. of the gross receipts payable to the London Platino Brazilian Telegraph Company, Limited, were £2,516.

City and South London Railway. The receipts for the week ending 24th April were £807, against £784 for the same period of

last year, or an increase of £23. The total receipts to date from January 1, 1892, show an increase of £1,110, as compared with last year.

West India and Panama Telegraph Company, Limited.—The Directors of this Company recommend dividends for the six months ended December 31, 1891, of 6s. per share on the first and second preference and 6d. per share on the ordinary shares, carrying forward £2,123. The receipts for the half-month ended April 15, were £2,673 against £3,661. The December receipts, estimated at £4,878, realised £4,914.

Brazilian Submarine Telegraph Company.—The report of this Company for the half-year ended December 31 states that the revenue amounted to £127,085, and the working expenses to £32,486. After providing for debenture interest, sinking funds, and income tax, there remains a balance of £80,682, to which was to be added £28,211 brought forward, making a total of £108,893. First and second interim dividends amounting to £39,000 have been paid, and £50,000 transferred to the reserve fund, leaving £19,893 to be carried over. In accordance with the provisions for repayment of the first issue of debentures, dated July 31, 1884, 168 bonds, representing £16,800, were drawn on the 11th inst. for payment at par on July 30 next. This, with the previous drawings, will make a total repayment of £113,600, leaving £36,400 of the first issue of debentures outstanding.

Elmore's French Patent Copper Depositing Company, Limited.—The Directors of this Company announce the issue of 60,000 preference shares of £2 each, on which interest at 10 per cent. per annum is guaranteed for the first year from the date of payment of instalments by Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited. There are reserved for allotment to the existing shareholders in the Company 40,000 shares, and the remaining 20,000 are now offered for subscription. The Company was formed in September 1890, with a capital of £400,000, for the purpose of applying the system of copper deposition, invented and patented by the Messrs. Elmore, to the manufacture of copper articles direct from the rough copper plates. The preference shares are entitled to 5 per cent. additional (making 15 per cent. in all) out of the surplus available for dividend after the ordinary shares have received 15 per cent.

Johannesburg.—The African Banking Corporation invite subscriptions until Saturday to an issue of 7 per cent. mortage debentures of the Johannesburg Lighting Company, Limited, in bonds of £50 each, part of an authorised issue of £60,000, and, at the option of the holders, convertible into ordinary shares of the Company, repayable at par on December 31, 1901. The Directors are: W. Garland Soper, Esq., J.P., chairman (chairman of the London Board Johannesburg Water Works Estate and Exploration Company, Limited); W. M. Farmer, Esq. (director of South African Gold Trust and Agency Company, Limited); S. Hughes Hewitt, Esq., South Aubyn, Kingston Hill, Surrey; Alfred Jones, Esq. (director of Durban-Roodepoort Gold Mining Company, Limited); W. F. Lance, Esq., managing director, Johannesburg. Trustees for the debenture holders: Lieut.-General Sir T. L. J. Gallwey, R.E., K.C.M.G. Terrace House, Roehampton; Archibald Parker, Esq., 2, East India-avenue, E.C. Bankers in London and South Africa: African Banking Corporation, Limited, 43, Threadneedle-street, London, E.C. Solicitors: Messrs. Ashurst, Morris, Crisp, and Co., 17, Throgmorton-avenue, E.C. Auditor: W. F. Turner, Esq., chartered accountant,, 20, Great Winchester-street, E.C. Secretaries and registered offices; Messrs. Davis and Soper, Bury-street, St. Mary-axe, E.C. The Company has acquired two concessions of the Government of the South African Republic for 99 years, for supplying gas and electric power for public and private lighting, heating, and other purposes in the town of Johannesburg; and the electric concession extends to the suburbs of Johannesburg. By terms of the concession no street lighting, whether by gas or electricity, can be carried out by any public authority, except through the Company. Contracts have been made, or are in course of negotiation, for the supply of incan descent lighting to the Postal and Telegraph Offices, the Grand National Hotel, the Central Hotel, Heath's Hotel, the Globe Theatre, the club, and other buildings. The demands for electric lighting are in excess of what the Company at present can supply. It is estimated that the net revenue from gas and electricity, irrespective of the residual gas products will, on the carrying out of the concessions, amount to £20,000 per annum.

PROVISIONAL PATENTS, 1892.

APRIL 19.

7361. **Improvements in the distribution of electricity by alternate currents.** Wilfrid L. Spence and Benjamin Deakin, The Elms, Seymour-grove, Manchester.

7398. **Improvements in telephone receivers.** Edwin Charles Hess, 321, High Holborn, London. (Complete specification.)

7404. **Improvements in or relating to electric railways and to dynamo machines and motors.** Sidney Howe Short, 18, Buckingham-street, Strand, London. (Complete specification.)

7412. **An improved battery element.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London.

7415. **Improvements in and relating to electric railways.** *Mark Wesley* Dewey, 45, Southampton-buildings, Chancery *lane, London. (Complete specification).*

APRIL 20.

7466. **Improvements in electrical communication on railway trains.** Alexander Shiels, 70, Wellington-street, Glasgow.

7487. **Improvements in electric switches.** William Arthur Smith Benson, 24, Southampton-buildings, Chancery-lane, London.

7488. **Improvements in electric arc lamps.** Henry Tipping, 55, Chancery-lane, London.

7492. **Improvements in and connected with electric bells.** Hermann Oppenheimer, 34, Aldermanbury, London.

7509. **Improvements in alternating-current electromagnetic motors and methods of operating the same.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (William Stanley, jun., and John Forest Kelly, United States.) (Complete specification.)

7515. **Improvements in electric insulating composition.** Thomas Griffiths, 54, Fleet-street, London.

APRIL 21.

7569. **Improvements in apparatus for automatically operating electric lamp switches.** Percival Everitt, 4, South-street, Finsbury, London.

7570. **Improvements in insulators for electric installations.** William Thomas Sugg, 6, Bream's-buildings, Chancery-lane, London.

APRIL 22.

7593. **Improvements in frieze and cornice borders and dado decorations for electric fittings.** Sir William Vavasour, 6, Ropemaker-street, Finsbury-pavement, London.

7629. **An electrically-propelled canoe.** Charles Edward Masterman and Woodhouse and Rawson United, Limited, 28, Southampton-buildings, Chancery-lane, London.

7646. **Improvements in electric switches or contact makers.** Henry Alexander Mavor, William Arthur Coulson, Sam Mavor, and William Brooks Sayers, 46, Lincoln's-inn-fields, London.

7649. **A new or improved electric bell push or pull, etc., automatic indicator.** Illius Augustus Timmis, 2, Great George-street, Westminster, London.

7655. **Improvements in electrical call and indicating apparatus.** George Richard Nunn, 6, Bank-street, Manchester.

APRIL 23.

7682. **An improvement in electromotors, applicable also to dynamo-electric machines.** Francis Price, Bristol Bank-buildings, Bristol.

7690. **Improvements in electromotors.** John Augustine Kingdon, 29, Marlborough-hill, London.

7717. **Improvements in electric alarm apparatus for use in connection with railways and vehicles, or trains travelling thereon.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Démetre Murguletz, Roumania.)

7718. **Improvements in or connected with electric arc lamps.** William Hopkin Akester, 57, Chancery-lane, London.

SPECIFICATIONS PUBLISHED

1888.

4626*. **Electrolytic production of metals.** (Amended.) Hoepfner.

1890.

15536*. **Telephone receivers.** (Amended). Collier.

1891.

8457. **Electric arc lamps.** Spokes.

8963. **Wiring for electric lighting, etc.** Sisling and others.

9227. **Telephones.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

9249. **Electromagnets for holding tools, etc.** Rowan and M'Whirter.

10261. **Electric motors.** Pieper.

10612. **Electrical transformers.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

1892.

2225. **Purifying electrolytes.** Nahnsen.

3971. **Electric propulsion of vehicles.** Mills. (Johnson.)

3996. **Electric adhesive plasters.** Thompson. (Shults.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2⅜
India Rubber, Gutta Percha & Telegraph Co.	10	20⅛
House-to-House	5	5⅝
Metropolitan Electric Supply	—	8⅜
London Electric Supply	5	1
Swan United	3⅛	4¼
St. James'	—	8⅞
National Telephone	5	4½
Electric Construction	10	6¼
Westminster Electric	—	6⅝
Liverpool Electric Supply	5	5¼
	3	3

NOTES.

Cheltenham.—Prof. Ayrton has been called in to report on the borough surveyor's scheme for lighting Cheltenham.

Electric Cooking. — A demonstration of electric cooking was given at South Shields last week by Mr. Farquhar Laing.

Barnsley.—The electric lighting scheme for Barnsley is still under discussion after a visit to Bradford, but no decision has yet been arrived at.

Blackpool.—The Blackpool Corporation invite tenders, in an advertisement elsewhere, for the seven years' concession to run tramways in that town.

Leeds Victoria Hall.—The Leeds County Council, on the motion of Sir Edwin Gaunt, have decided to adapt the fittings in Victoria Hall as electroliers.

Aberdeen.—The Aberdeen Town Council on Tuesday agreed to invite Prof. Kennedy to visit Aberdeen and report upon the best mode of electric lighting.

Liverpool.—Mr. W. H. Preece, in a lecture at Liverpool, pointed out the possibility of utilising the Vyrnwy water power for transmission to Liverpool.

Glasgow.—It has been resolved by the Glasgow Corporation Electric Lighting Committee to erect 106 lamps in the principal thoroughfares next winter.

Assessment.—The Crystal Palace District Electric Lighting Works at Sydenham have been provisionally assessed at £500 by the Lewisham Guardians.

Leeds.—An advertisement will be found elsewhere inviting tenders for the supply and erection of machinery for a central electric station at Leeds by May 26.

Society of Arts.—An article will be read by Mr. G. L. Addenbrooke on Wednesday, May 11, before the Society of Arts, on "Uses and Applications of Aluminium."

Barnet.—The arbitration case between Mr. Joel and the Barnet Local Board, of which two meetings were held last week, comes on again for examination next Monday.

Hospital Lighting.—The London County Council have sanctioned the electric lighting of the Ophthalmic Hospital, St. George's-circus, by the Electric Supply Company.

Internal Lighting.—Mr. W. H. Preece will read a paper on the 16th inst. before the Royal Institution of British Architects, on "The Art of the Internal Illumination of Buildings."

Tunbridge Wells.—A petition, bearing numerous and influential signatures, has been presented to the Town Council at Tunbridge Wells, asking for private and public electric lighting.

Board of Trade Unit.—The Board of Trade have decided that the unit of 1,000 watt-hours shall be termed the "kelvin," and in provisional orders just granted have altered the terms accordingly.

Electric Testing of Milk.—The *Chemiker Zeitung* describes experiments in the testing or analysis of milk by electric current, based upon the change in resistance of liquids by the addition of oil or grease.

Mr. Tesla.—The many friends of Mr. Tesla will be sorry to hear that he has sustained a severe loss in the death of his mother, to whom he has been on a visit. Owing to this loss he is still detained in Montenegro.

Book Received.—We have received from Messrs. Spon a copy of the new edition, greatly enlarged, of Prof. S. P. Thompson's work on "Dynamo-Electric Machinery," which is now included in the Finsbury Technical Series.

Dalton.—The surveyor to the Dalton Local Board has been instructed to prepare specification for street lighting. Mr. Geo. Peers has written to the Board with reference to electric lighting, and the clerk has been instructed to reply.

Warrington.—The Warrington Gas Committee wish to ask permission to borrow £30,000 for extension of gas works, but Alderman Harrison said that the electric light should be considered, and the recommendation was withdrawn.

Worcester.—The alternative plans of the alternating current and the storage distribution by the Brush Company or the Electrical Power Storage Company are still under discussion at Worcester. A decision is expected shortly.

Salford.—At the monthly meeting of the Salford County Borough Council on May 4, it was decided to expend £30,000, with the sanction of the Board of Trade, for an installation to supply electric lighting throughout the borough.

Southampton.—Tenders are required by May 16 for electric lighting the Southampton Corporation Baths. Specifications may be obtained and plans seen on application to Mr. J. G. W. Aldridge, 9, Victoria-street, Westminster, and 23, High-street, Southampton.

Institution.—The Institution will meet next Thursday, May 12, when the discussion on Mr. Trotter's paper on the "Light of the Electric Arc" will be continued, and a paper will be read "On the Cause of the Changes of E.M.F. in Secondary Batteries" by Dr. J. H. Gladstone, F.R.S., and W. Hibbert.

Calibrating Dynamo.—A useful piece of apparatus in a factory or laboratory is the calibrating dynamo, designed by Mr. Frederick La Roche, of Philadelphia. This dynamo has a range of from ·02 to 12,000 volts, and is used in the instrument factory of Queen and Company for direct calibration of instruments.

Pretoria.—With reference to the progress of electric lighting in South Africa an erroneous allusion was allowed to pass last week upon the town of Pretoria, which, as is well known, is being fitted up with a complete electric central station system by Messrs. Crompton and Co., and the contract is now on the very eve of completion.

Colombo.—At a meeting of the Colombo Municipal Council it was agreed, on entering upon the gas contract for a more extended period, to make a reservation in the case of the Fort Ward. This reservation was made on the suggestion of Mr. Walker, who stated that representatives of an electric lighting company in London had been prospecting in Colombo.

Electricity in the Household.—Messrs. Drake and Gorham have obtained the contract for the electric lighting of Lawnhurst, for Mr. Simon. The light is to be employed throughout the whole of the large building, and the current is also to be used for driving a workshop, blowing an organ, and other purposes, for which its convenience is becoming every day more appreciated.

Shrewsbury.—The Shropshire Electric Light and Power Company are advertising their powers under the provisional order in accordance with the Board of Trade regulations. The address of the company is 9, The Square, Shrewsbury, or Messrs. Chester, Mayher, and Broome, 36, Bedford-street. Plans of the proposed areas to be lighted are shown at these addresses.

Chicago Lighting.—The Thomson-Houston Company have been given a contract for the lighting at the Chicago Exhibition for 2,500 arc lamps at 20dols. each, without superintendence. The Standard Company, of Chicago, are to be given 1,000, and the Western Electric Company 500 on the same basis. It is still thought of seeking some lamps from English contractors.

Electric Submarine Boat.—It is stated that a novel kind of submarine boat has been launched at Savona by an Italian engineer, Signor Abbatti. The boat is designed for fishing and recovering lost property. It is driven by an electric screw, and is capable of remaining under water, so it is stated, for six hours at a depth of 330ft. A first trip is to be made shortly from Civita-Vecchia.

Derby.—At the meeting of the Derby Town Council on Wednesday, a recommendation was made for the Corporation to undertake the lighting of the central part of the town, both public and private property, with electricity, and £30,000 was asked for to defray the cost of the installation, with engines, dynamos, and underground mains. The recommendation was unanimously adopted.

Accident.—We are sorry to have to report a shocking fatal accident to William Pemberton Bannister, 22 years of age, who accidentally got his legs entangled in an electric coal-cutting machine at Glass Houghton Colliery, Castleford, where he had been sent to superintend the experiments. He was removed to Leeds infirmary, but was so seriously injured that he expired shortly afterwards.

Provisional Orders.— Mr. Campion, one of the examiners on standing orders of the House of Commons, has found compliance in the case of the Electric Lighting Provisional Order Bill which proposes to confirm certain provisional orders made by the Board of Trade under the Electric Lighting Acts of 1882 and 1888, relating to Sutton (Surrey), West Ham, Woking (Horsell and Chertsey), Kilkenny, and Newbury.

Books on Electricity.—Mr. Bernard Quaritch sends us his catalogue of rare and second-hand books, among which are several upon electricity and magnetism. There is De la Rive's "Treatise on Electricity," translated by C. V. Walker; Faraday's "Researches," original issue and the reissue; Franklin's "Experiments and Observations," bound together with Hoadby and Nairne; and a copy of Gilbert's "De Magnete" (Londini, 1600).

Electricity in Papermaking.—In a note, on the 22nd, on the above subject, we stated that Mr. Bevan in his lecture mentioned that the manufacturer could produce at a daily cost of £133 chemicals which at present cost him £300. Mr. Bevan writes to us, from 4, New-court, to say that this hardly represented what he stated, which was that alkali and bleaching powder could be produced at a cost of about one half the present selling prices.

Blackpool Winter Garden.—The Art, Trade, and Industrial Exhibition was opened at Blackpool Winter Gardens on Wednesday. A special feature of the exhibition is the display of electric lighting. Two firms make an excellent show. Messrs. Laing, Wharton, and Down light up the Floral Hall, promenade, and rink with about a dozen Thomson-Houston arc lights, while the Corlett Electrical Engineering Company will also light the pavilion by means of arc lamps.

Colombo Tramways.—The Chairman of the Municipal Council of Colombo (Mr. H. Hay Cameron) will receive proposals for the construction of tramways in Colombo, Ceylon, up to the 30th September, 1892. Principals only will be dealt with as regards the concessions. Copies of draft of concessions with plan of street and gradients can be obtained on application at the Municipal Office, Colombo, and any further information as to traffic will be supplied by the chairman of the Council.

Newark.—At the last meeting of the Newark Urban Sanitary Authority, the Mayor, in reference to the electric lighting question, mentioned that Messrs. Quibell, Knight, and Norledge and himself had been to the Electrical Exhibition in London, and had seen Messrs. Crompton; and Mr. Sheppard, who was always ready to help in such matters, had undertaken to prepare certain engineering particulars for the committee. He did not think they would be able to have the electric light this year.

Whitehall Club Dinner.—Arrangements have been made for a dinner of the electrical engineering members of the Whitehall Club at the Crystal Palace on Wednesday, May 25. Special demonstrations will be given by Messrs. Crompton and Co., of electric cooking; Messrs. Laing, Wharton, and Down, of Prof. Elihu Thomson's experiments; and by Messrs. Siemens and Swinburne and Co., of high-tension experiments. Mr. W. H. Preece, F.R.S., will take the chair. Members have the opportunity to invite friends.

Wakefield.—A grand bazaar has been held at Wakefield, in the Corn Exchange, in celebration of the Wakefield Cathedral improvements. Mr. H. M. Edwards, of the Cardigan Works, provided two electric lamps of 1,000 c.p. each—one being on the landing of the staircase, and the other in the Merchant's Hall. The electricity was supplied from a dynamo affixed in the yard of The Bull Hotel, under the superintendence of Mr. Edwards, jun., which was worked by a gas engine lent for the occasion by Mr. J. J. Martin.

Staffordshire Industrial School.—The Industrial Boys' School Committee of the Staffordshire County Council, having repeated recommendations of high authority before them, have come to the decision that it was more desirable to adopt lighting by electricity, and therefore asked the Council to authorise an expenditure not exceeding £900 for that purpose. After considerable discussion this was referred back to the committee, with a desire that they should furnish the Council with further information thereon.

Government Enquiries.—In the House of Commons, on the 28th inst., in reply to Mr. Bartley, Sir M. Hicks-Beach said that in cases where objection to an application for a license or provisional order under the Electric Lighting Acts is made by any person locally interested, the Board of Trade do, if they consider it expedient, hold a local enquiry; but the circumstances of different applications vary so much that it is impossible to lay down any definite rule as to the grounds which would justify the holding of such an enquiry.

Burnley.—The electric lighting scheme for Burnley is awaiting the sanction of the Local Government Board for power to [illegible]rrow £25,000 for [illegible] lighting. Until this is obtain[illegible] [illegible]eme has be[illegible] ing L[illegible] gearing, [illegible] tension system with [illegible] cations are being p[illegible] sanction of the Local Go[illegible]

[illegible]MPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
[illegible]	—	$3\frac{1}{4}$
[illegible]	—	$2\frac{3}{8}$
[illegible]elegraph Co.	10	$20\frac{1}{4}$
[illegible]	5	$5\frac{5}{8}$
[illegible]	—	[illegible]

South Shields.—The m[illegible] poration are exercised in their [illegible] reference to the gas supply of the present company. A special committee has been appointed to consider the question of municipal gas works, and no time should be lost in bringing before this committee the results of Bradford and St. Pancras with municipal electric lighting. In Stockton, where gas

is at 2s. 6d. per 1,000, with a consumption of one-third less than South Shields, the Corporation make a profit of £5,000 a year, and with their own works the South Shields Corporation should be in a good position with either gas or electric light to make a profit.

Moffat.—The Moffat Police Commissioners had before them on Monday night a report by Prof. Jamieson, Glasgow and West of Scotland Technical College, upon a proposal to light the streets of Moffat by electricity, the motive power being obtained from Evan water, two miles distant. The several schemes were discussed at considerable length. It was remarked they would entail an annual cost double or treble the present cost of lighting by gas. Eventually a motion by Bailie Knight, to postpone further consideration of the schemes till after the election in November, was carried as against the proposal by Mr. Brown for an immediate appeal to the ratepayers.

Halifax.—The Board of Trade have decided to grant to the Corporation of Halifax a provisional order for the electric lighting of the area comprised within the county borough. The Corporation are placed under an obligation to lay distributing mains within a period of two years after the commencement of this order along the principal thoroughfares expressly mentioned in a schedule attached to the order. The order will come into operation immediately upon the passing of the Bill confirming it, and in the event of the mains not being laid within the time stated the Board of Trade reserve to themselves the right to revoke the whole or any part of the order.

York.—The town clerk of York has issued a circular stating that a proposal will shortly be submitted to the City Council that they shall exercise at an early date powers which the Corporation have obtained for lighting the city by electricity. In order that the Electric Lighting Committee may be strengthened in any recommendation they may make to the Council, they are desirous of being able to refer to promises by residents and occupiers to take a supply of electricity for the lighting of their houses and establishments, and the object of the enquiry is to obtain such promises. The circular is accompanied by a pamphlet respecting lighting by electricity.

Electric Launch at the Crystal Palace.—Messrs. Woodhouse and Rawson have lately added to their stand at the Crystal Palace an electric launch, and the following particulars concerning this boat will be of interest. The "Lily," as she is named, is 28ft. long, and has a beam of 5ft. 6in., a depth 2ft. 10in., and a draught of 2ft. The sides of the boat are carvel, built of mahogany, with American elm keel and timbers, and she has an oak stem, stern-post, and dead-wood. The electrical equipment consists of a 2-h.p. "W & R" motor, supplied with current from 30 Epstein cells. The weight of the boat complete is 25cwt. She will hold from 12 to 15 passengers, and with one charging, which occupies about four hours, will run at full
...uncil at Tunbridge Wells, asking ... private
electric lighting. ... committee,

Board of Trade Unit.—The Board of Tra... last week decided that the unit of 1,000 watt-hours shall ... company the "kelvin," and in provisional orde... supply Bray's patent altered the terms accordingly. ... the main thoroughfares what terms. It was also

Electric Testing of Mil... ...pany whether they were pre-
describes experiments in the ... present terms and conditions for
... based u...
public lighting. ... Willey expressed the opinion that Exeter was very badly lighted. In the main streets the lamps were very small, and in the suburban districts they were of a primitive description. Mr. Thompson did not think they would get the streets of Exeter lighted as they would wish to see them until they had electricity.

Glasgow Technical College.—Mr. Andrew Stewart has presented a handsome screw-cutting lathe to the electrical engineering laboratory connected with the Glasgow and West of Scotland Technical College. Prof. Jamieson, who presided at the presentation on the 20th inst., said that the lathe was the best in proportion to its size in Scotland. Mr. Stewart then made the presentation. He trusted that the work that was turned out with the machine would be done with thought and care. Mr. Russell, of Ascog, on behalf of the directors, received the gift. The machine, it may be stated, was made by Messrs. John Lang and Sons, lathe manufacturers, Johnstone.

Portsmouth.—Renewed experiments with electric lamps have been conducted at the Portsmouth Town Hall, and the Electric Lighting Committee have come to a decision as to the pattern of lamp which shall be adopted for street lighting. They have chosen for the ordinary streets Edison-Swan incandescent lamps of 200 c.p., which will be placed at distances of about every 50 yards in the thoroughfares to be lighted. The existing gas columns, which stand about this distance apart, will be used for the new lamps in almost every case. The Clarence Esplanade, from one pier to the other, will be illuminated by powerful arc lights of the Brockie-Pell pattern. It is expected that the Local Government Board will in about six weeks' time give their sanction to the borrowing of the £60,000 for the whole work, which will then be taken in hand forthwith, the committee being desirous of completing the installation before the close of the year.

Smithfield Markets.—We mentioned a few weeks ago that a proposal has been made by Messrs. Julius Sax and Co., of Ridgmount-street, to the Markets Committee of the Corporation of London to light the avenues of the Central Markets at West Smithfield free of charge, in return for a concession for the lighting of the markets at a price not exceeding the Board of Trade rate. This offer has now been unanimously accepted by the Markets Committee, and the project will have a considerable interest among municipal electric lighting schemes. Messrs. Julius Sax and Co. propose to illuminate all avenues of the markets with 100 Edison-Swan incandescent lamps of 50 c.p. each, which will relieve the Corporation of a considerable annual expense for gas. The firm has also undertaken to supply each of the Corporation's tenants with not less than 10 lamps, at the rate per unit which from time to time shall be fixed by the Board of Trade.

Search-Lights on Battle-Ships.—Lieutenant W. B. Lefroy Hamilton in a recent article on electricity in the U.S. Navy refers to the working of the search-light. He says that in the practical use of the search-light it has been found that, in order to afford a sufficient time for a careful examination of the water's surface at points far removed from the ship, the beam of light must be revolved very slowly, and therefore during a great portion of the time much of the surrounding water is left in darkness. As it only takes five minutes for a torpedo-boat to run a distance of two miles, it is easily seen that in the interval between two successive illuminations of the same spot a torpedo might attack a warship and discharge her weapon. To overcome this difficulty it is proposed that the new American warships, beginning with the "New York," shall be fitted with a number of stationary search-lights grouped together, each illuminating its own section, thus keeping the ship surrounded by an unbroken circle of light.

Taunton.—The report of Mr. Kapp, as valuer for the Taunton Corporation of the electric light station, has been awaited with great interest, as it was felt that upon that would depend the action of the Corporation on the per

posed purchase of the station, which has been urged upon the town. We are not able to give Mr. Kapp's report as yet in full, but the following abstract is given in the local paper: "We understand that the valuer estimates the total value of the works at between £6,000 and £7,000. He further points out that some of the plant so valued would be worth nothing to the Council, thus reducing the purchasable plant to about £5,000. He also gave an unfavourable opinion as to the site of the electric works, and is not satisfied that the system followed is the best attainable. Altogether the report is most discouraging to the shareholders and to townspeople generally. Something definite will have to be done without delay, else the light will go out and the front streets will be in darkness till the gas lamps can be got up into position again."

Exeter-Plymouth Telephone.—The telephone trunk line connecting Exeter to Torquay and Plymouth was opened last week, and this last result of the enterprise of the Western Counties Telephone Company is likely to prove of considerable utility to the inhabitants of South Devon. The experiments organised at the opening of the line by Mr. J. A. Bonathan, the superintendent of the Exeter exchange, were extremely successful. Speaking first to Torquay, listeners in Exeter were delighted with the clearness of enunciation of persons 30 miles away, and this was not less the case with speakers at Plymouth, 62 miles distant. Teignmouth and Dawlish will shortly be connected, completing the exchange between all the important South Devon towns. The trunk tolls from Exeter (in each for three minutes' conversation, are as follow: Telephone to Newton Abbot (22 miles), 6d.; Torquay (28½), 6d.; Paignton (32), 6d.; Brixham (40½), 9d.; Dartmouth (44), 9d., Totnes (38½), 9d.; Buckfastleigh (45), 9d., Ashburton (48), 9d., Plympton (58), 9d.; Plymouth (62½), 9d.; Rame Head (98½), 9d.

Lighthouse Beams.—Lieut. Albert G. Froud, R.N.R., secretary to the Shipmasters' Society, 60, Fenchurch street, has the following letter in the *Times*: "The 'Eider's' wreck during fog, and the ensuing newspaper correspondence, have brought home to the general public that gap in the effective continuity of coast lights and signals which this society has been endeavouring to help in bridging over—'thrills of light, as recommended by Prof. Tyndall; the sky-flashing signals of Mr. John Wigham; vertical beams of light, as suggested by this society; and sound signals bursting in the air and giving out a shower of white or coloured stars at a high elevation. All these are available, and in the opinion of the committee of management are likely to serve the purpose. To help in further testing the committee's suggestion, Mr. Ronald A. Scott, an exhibitor who aided them at the Royal Naval Exhibition, has again volunteered to project a vertical beam of light from the Crystal Palace at 9 to 9.15 of every weekday evening during the month of May. The committee will be much obliged if you give prominence to this announcement, and the notes of any observer will be thankfully acknowledged."

International Horticultural Exhibition.—In the forthcoming International Horticultural Exhibition at Earl's Court the building and grounds are lit by 210 10 ampere arc lamps, run 30 in series, and the effects in the arena (Buffalo Bill) are obtained by 11 40-ampere projectors with special reflectors, and which also have a novel self-regulating attachment. In the engine-room there are eight 30-lighter series arc machines, two compound 17-unit machines for the projectors, two Mordey alternators with exciter to run 600 to 1,000 incandescent lamps, with Mordey transformers, supplied by the Brush Company. *Davey-Paxman* engine and boilers are used—viz., one 80 and two 40 nominal horse-power engines and four 40 nominal horse-power locomotive multitubular boilers, running a countershafting divided into three sections to meet emergency or breakdown, the dynamos being run from this shafting. The centre fountain in the Grand Hall is an attractive item. Its coloured incandescent lamps are controlled by an automatic switching arrangement, actuated by a waterwheel, the combination of which was specially designed by the electrical engineer to the exhibition, Mr. A. H. Wood. The time for erection has been very short indeed. Orders were only received five weeks ago, and as the former contractors, of course, removed their plant, it necessitated the building and grounds being reinstalled, and the making of all arrangements with the contractors as well as erection of the plant.

Blackpool.—The electric lighting question has assumed considerable prominence in local politics at Blackpool. Correspondents have been discussing the subject with a timorous air in the *Blackpool Gazette*, and the following is the summary that the paper gives of the present state of the problem: "Authoritative details of the scheme to be submitted to the Corporation are not yet forthcoming. An electric lighting committee has been at work for several months. They have journeyed up and down England, and spent about a fortnight in London. Then most of the principal electrical firms have sent representatives to Blackpool in order that no opportunity might be lost of obtaining a remunerative order, and members of the committee, individually or otherwise, have been called upon either to entertain or be entertained by these gentlemen. It would appear for some time back several of the committee must almost have abandoned their everyday avocations, and devoted themselves entirely to the study of electricity. When their report is forthcoming, therefore, it may be expected to be a marvel of electrical research, and replete with facts upon this important subject. This document is awaited with no little degree of interest, and if it sees the light at the next meeting of the Town Council some comment upon it may naturally be expected. At present there is every evidence that the ratepayers are inclined to be rather dubious about the electric lighting business, but what sort of a reception the long waited report will receive remains to be seen."

Willesden.—The inhabitants of Willesden have been startled by the fact that nearly all their gas bills have gone up with a bound during the last quarter, in some cases as much as 70 per cent. An indignation meeting has been held, the chairman deliberately stating that they had been swindled. Mr. C. Eden suggested approaching their member of Parliament. It was understood that the increase was explained by the company on the score of increase of pressure. Mr. Collins proposed that the Local Board should institute an enquiry. This was carried, and Mr. Tickner next proposed that the Local Board be requested to consider the advisability of starting electric light works for the district forthwith. A gentleman suggested the use of the River Brent. Mr. Hart, on behalf of a company, submitted a scheme for electric lighting, and said his scheme was already before the Local Board. He expressed himself ready to provide the fittings free, and lay on the electric light to every house, at a price not exceeding the present price of gas. Mr. Chas. Eden is acting as secretary of the movement, and a committee of the principal consumers is to be appointed. It is right to say that the gas company have in some cases accepted payment for much less than the demands, upon representations by the consumer, but that the complaint is well founded is shown by the fact that the average increase of gas for 25 of the principal tradesmen was found to be 70

per cent.—£98 increased to £153 for practically the same light.

Electrical Engineering Problems.—An interesting and suggestive paper was given recently before the Dundee Mechanical Society by Mr. Thomas Reid, assistant professor of engineering at the University College, on "Electrical Engineering Problems." The lecturer remarked on the tendency of electrical station designers to follow the pioneers; he alluded to the advantages of rope gearing, and said it often seemed to be assumed that when triple-expansion engines were used they had done all that was possible, yet, as a matter of fact, there were stations where better results could be obtained by dispensing with one of the cylinders, as when the engine was running light the consumption of steam to run the engine itself was a large fraction of the total. He was not aware of many plants in England which used less than 25lb. of steam per horse-power hour, while in Berlin it had been reduced with large load factors to 15lb. or 16lb. Engines should be designed, in conjunction with electrical plant, to maintain a constant pressure by changing the speed, and keeping the cut-off nearly constant, thus always at full load for that particular speed. Larger dynamos and engines could be used and kept steadily at work. With reference to boilers, the same follow-my-leader style had been adopted without due consideration. Water-tube boilers were used, but unless internally fired they gave rise to great radiation. He recommended Lancashire boilers of fairly large capacity to work in conjunction with internally-fired water-tube boilers of small water capacity. Gas firing might be used, one advantage being that corporations owning both gas and electrical plants could use them with mutual advantage.

Flour-Mill Lighting at Lynn.—Some large flour mills have recently been erected at Lynn, Norfolk, by Mr. J. M. Bird, of Downham. The mill, constructed from designs of Messrs. Whitmore and Binyon, is capable of turning out about 1,200 sacks (280lb. per sack) of flour per week, and when in full operation night and day will give employment to some 40 hands. The engine and boilers are supplied by Messrs. Woodhouse and Mitchell, of Brighouse, Yorkshire. There are two Lancashire Galloway-tubed boilers (to be used alternatively), each 21ft. long and 7ft. in diameter, working at a pressure of 90lb. The feed-water is heated by a Green's economiser. The engine, a tandem horizontal compound condensing, is fitted with Corliss valves, and has a stroke of 3ft., the high-pressure piston being 12in. in diameter, and the low-pressure 22in. The flywheel, which is 14ft. in diameter, is grooved for eight cotton ropes, each about 1in. thick; of these five are 90ft. long, and drive the rolls and wheat-cleaners; the other three are 130ft. long, and convey the motive power for the purifiers. The engine also drives the machinery for the electric lighting, and there is a vertical 4-h.p. engine to be used for this purpose when the larger one is not in motion. The dynamo is a No. 2 Crompton compound wound, capable of supplying 90 incandescent lamps of 16 c.p. The lighting is divided into circuits, which are controlled in the engine-room by Hartnell's patent double-pole switches, fitted with safety cut-outs, and provision is made for measuring the quantity of current and pressure. The lamps are of the Edison and Swan patent collar type, and are suspended by flexible incombustible leads, each fitted with a cut-out. Each floor has its own switch for turning the lights on or off. The whole of the lighting apparatus is supplied and fixed by Mr. Wilson Hartnell, of Leeds.

Royal Society Conversazione.—The annual *conversazione* of the Royal Society, held on Wednesday evening, included some very interesting electrical exhibits. In the first room Dr. J. T. Bottomley showed vacuum tubes without electrodes. The tubes were wrapped loosely with a twist of wire, and when connected with a Rhumkorff coil showed all the common phenomena of stratification, and are sensitive to magnetic influence. Dr. Oliver Lodge had an assortment of induction apparatus. At one experiment he showed the difference between negative and positive sparks. If sparks are sent from the outer coating of jars at the moment of discharge, water in a jar acts as a dielectric, and an explosive spark takes place as through oil. Flashes down an artificial rain shower were shown. But the most interesting was a model of the retina in tubes of copper. From these tubes of different diameters, arranged near a Hertz oscillator, sparks could be drawn from different distances along their length according to their diameter, imitating the theoretical conception of the nerves of the eye. A curious piece of apparatus was shown by Mr. E. E. Robinson, termed an electric harp. A glass plate covered with strips of tinfoil, with gaps in a sloping line across the plate, making various lengths of strip when placed within range of a Hertz oscillator, showed sparks on certain strips. Experiments with this seemed to prove that the Hertz oscillations included harmonic vibrations, as stops of one, two, four, etc., units length always showed sparks. Mr. Wimshurst exhibited Leyden jars, with wire coatings, which show new phenomena. Captain Holden had a very large selection of new instruments. The first, a high-speed chronographic pen with automatic resetting attachment, is a pocket arrangement for testing the speed of shot; in this a local circuit resets the stylus at each break of screen by a shot. Captain Holden also showed dead-beat direct-current ammeters of novel design, using the expansion of a solid conductor to bend over and move a pointer. This can be used as ammeter or as cross-current detector, and if set for 100 amperes will pass 99 and go at 100. Alternating-current ammeters and galvanometers were also shown. All these instruments were made by Mr. J. Pitkin for Captain Holden, and are marvels of finish and accuracy. Mr. Wm. Crookes exhibited some exceeding interesting experiments with vibratory currents of 100,000 volts and a million alternations per second, and gave the audience the opportunity of taking such shocks. Vacuum tubes connected to one pole were brilliantly lighted by simply approach of a hand to the tube stream and brush discharges, and imitation St. Elmo's fire, phosphorescence of air and precious stones were also shown. Prof. C. V. Boys, during the evening, showed his experiments in photographing flying bullets. The most novel exhibit was that of colour photographs, by Mr. Frederick Ives, of Philadelphia, an invention we had an opportunity of seeing at Mr. J. W. Swan's house at Bromley, previously. The most interesting exhibit from the electrical engineer's point of view at the Royal Society was, however, the new dynamo by Messrs. Pyke and Harris. This has no moving coils and no moving magnets; the whole, except one turned ring, is made of castings and stampings, and is therefore remarkably cheap. A hollow mitis metal shell is rendered powerfully magnetic by an inner coil. The projections form the magnet poles, and these are surrounded by coils of wire screwed on. The electrical current is obtained by rotating a set of soft iron laminated pole-pieces only between the north and south magnets, the cutting of lines being thus obtained by the addition or subtraction of the iron. The 100-light machine stands only 21in. high, weighing seven hundredweight, and is remarkably small. All coils are safeguarded by cut-outs, and there is nothing to get out of order. Direct-current machines are also made on the same principle.

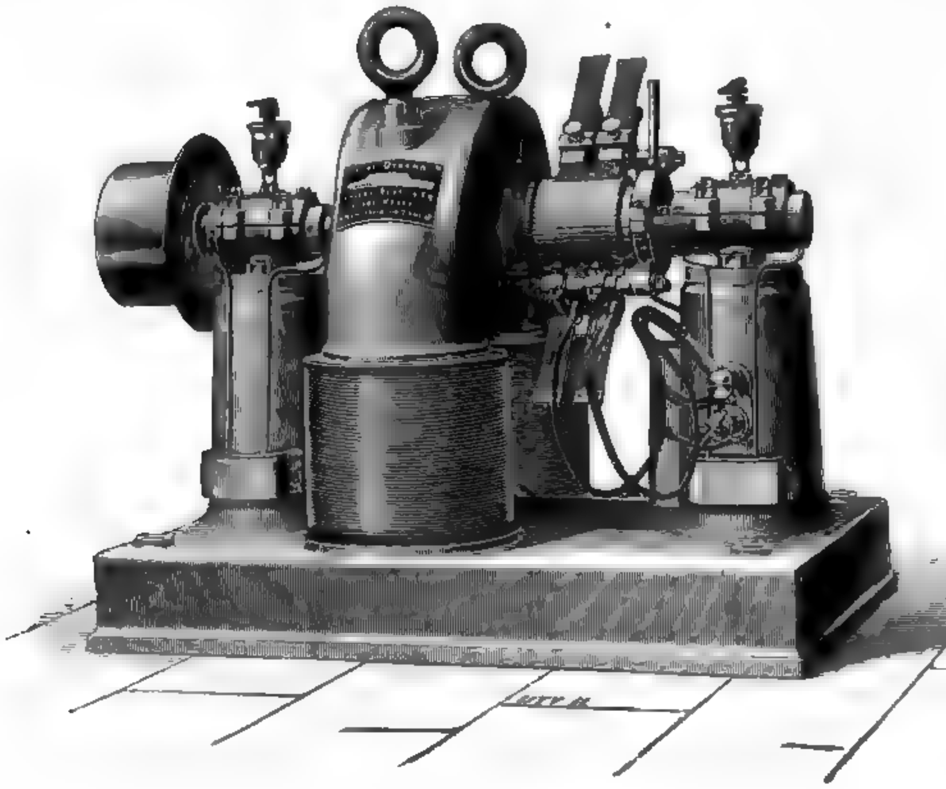
THE CRYSTAL PALACE EXHIBITION.

DIRECT-CURRENT DYNAMOS.—VI.

BY R. W. WEEKES, WHIT.SCH.

The Two-Pole Inverted Type.—This shape of field is now used by a large proportion of makers. The great advantage of the type is that with wrought-iron magnets the bed-plate forms the yoke, and that when the dynamo is to be made of cast iron the magnets and bed-plate may even be cast as a whole. In this type the poles are in such a position that all the leakage of magnetism takes place through the air, which fact gives a distinct advantage in material and workmanship over the two-pole upright type, in which brass or zinc sole-plates are needed to prevent leakage to the bed-plate. The magnetic pull on the armature, due to the greater density of lines in the parts of the polar surface nearest to the yoke, acts downwards, and increases the pressure on the bearing. This can be overcome by placing the armature so that its axis is slightly above that of the bore of the field magnets. The distance between the armature core and the pole is then greater on the under side, and this causes a more equal distribution of lines of force. The axis of rotation is much higher in a dynamo of this type than in a machine of the upright form of magnets of equal output. This makes the type unsuitable for coupling direct to engines, but the height of the axis renders the commutator easily accessible. It is worthy of note that no makers use this inverted type of field magnet for large-output dynamos, but it finds almost universal acceptance for cast-iron machines.

The Electric Construction Corporation.—The motor-generator made by this firm is the largest machine with this type of field shown in the Exhibition. The general details of it have been already given. The special feature in the field magnets is that they are laminated for convenience of manufacture, and also to secure uniformity of material, which cannot be absolutely relied on when large forgings are used. The lamination would also reduce eddy currents in the poles, if any were generated by the armature, as in the toothed cored type. The wrought-iron magnets are built up of plates, which vary in thickness according to the size of the machine, and are about 2in. thick in this case. These are obtained of the exact width required, placed at right angles to the axis of the machine, and then firmly bolted together. A distance-piece of wrought iron is inserted between them, thus forming the yoke. This end of the magnet is then bolted into a recess in the cast-iron bed-plate. It is in the boring of the magnet that the advantage of this lamination is obtained. Instead of removing the superfluous iron by successive cuts till the bore is of the diameter required, a thin tool is fixed to the boring head at the proper radius. This then cuts round the final diameter only, and the internal pieces fall out as each successive plate is pierced. Thus the boring is a more rapid process than when solid slabs are used, and the scraps are worth more. The poles are encased by thin cast-iron caps, which gives a well-finished appearance to the machine. The pedestals fit into recesses in the bed-plate, and in the larger machines the bearings are made adjustable, as described before. The floor space and weight efficiencies for both the motor-generator and 26-kilowatt motor are good. It must be remembered, when comparing the numbers on the list, that belt-driven machines like these have the bed-plate included in the weight, while most of the large-output dynamos are direct-driven, and then the weight of the bed-plate is not taken in. Hence these latter have the advantage, and should give the higher figures. These machines are the only ones exhibited of this type which have the complete magnetic circuit made of wrought iron.



Ernest Scott and Mountain's 6-kilowatt Dynamo.

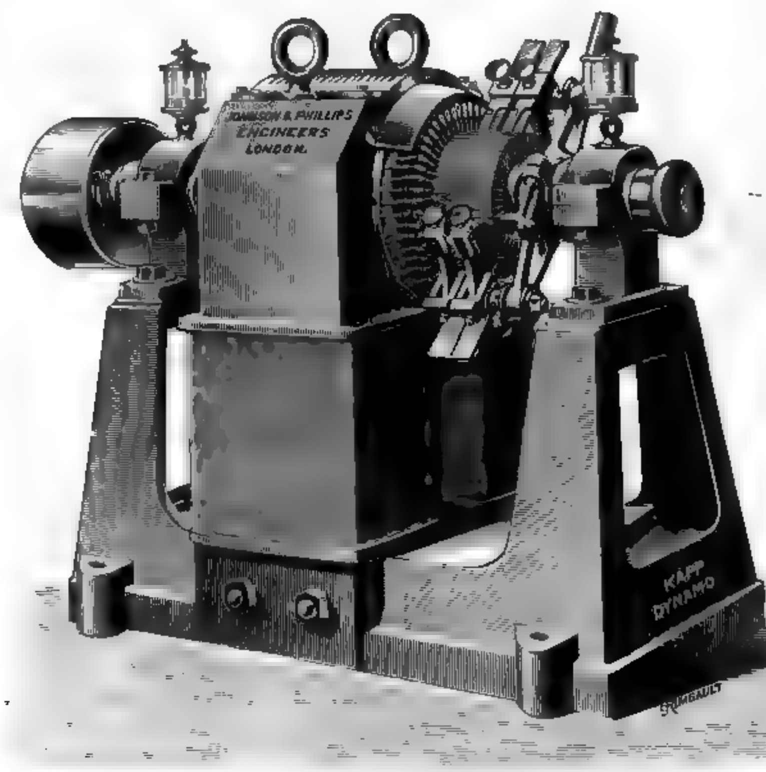
Messrs. Ernest Scott and Mountain show some two-pole dynamos, driven by the Fielding gas engines. The distinct feature in these machines is that the disc type of armature is used. The frame is made of cast iron, but the magnets cannot be cast on to the bed-plate owing to the shape of the pole-pieces, which would not allow the exciting coils to be slipped on. The pole-pieces are made to embrace the armature core in a somewhat similar way to that adopted in the larger four-pole machines made by this firm. The core is made of thin rectangular iron wire wound on to a brass centre till the cross-section is nearly square. Mr. Mountain claims an advantage in making the length of core longer than the depth, in the proportion of about 6 to 4, and he states that the E.M.F. produced per foot of armature conductor is higher in these machines than in any wound on the drum system. The great objection, however, is that the armature cannot be withdrawn without taking the magnets to pieces. In these two-pole machines the upper half of the pole-piece is made to lift off. The two parts have a faced surface where they join, and are keyed together to ensure accuracy of fit. Thus all the lines going to the upper half of the poles have to cross this joint, which places an additional resistance in their path. This

must increase the magnetic pull on the bearings considerably. The shaft runs in gunmetal bushes filled in with white metal, and one end has thrust rings turned on it to keep the armature core in the centre of the field. For a cast iron dynamo the use of embracing poles causes an unusual number of joints in the magnetic circuit (there being four), and it is very doubtful whether the advantage of a shorter length of wire on the armature is worth the extra magnetising power required in consequence. The extra joints cause a lot of fitting work, and the boring of the poles is a much more difficult operation than when the drum armature is used. I was privileged to see the works of this firm a few days ago, and noticed that they are using the Gramme ring type of armature for some large motors they are making to drive some pumps for a coal pit.

Messrs. Johnson and Phillips show a number of dynamos of this type on their stand in the centre court. These Kapp machines have been so often described in the various text-books on dynamos that the details should be well known. The magnet bars are slabs of wrought iron, which are bolted into recesses in the bed-plate. The cast-iron bed-plate is specially thickened in the centre, where the magnets join, so as to offer a low resistance to the magnetic

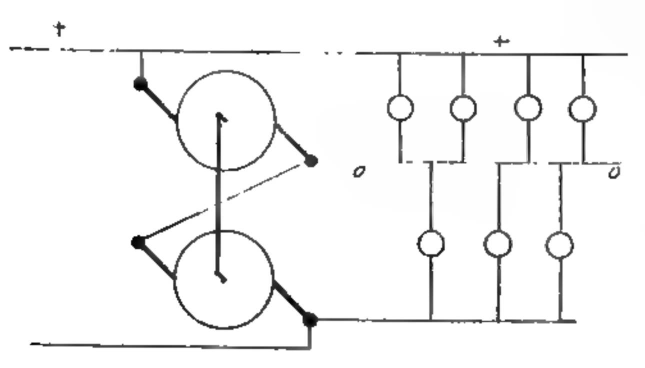
are arranged so that the junction is maintained at a potential difference of 70 and 130 volts from the other terminals respectively. This is to show the range of the balancing power. When each external circuit takes equal current, the motors run light, but directly the one side takes more current than the other part of the excess current returns through the machine in parallel with the other circuit. This machine then drives the other as a dynamo, and by supplying the other part of the excess current, tends to prevent any drop of voltage in the over-loaded circuit due to the want of balance. This method works exceedingly well, and such an equaliser can be used to supply all the current to the zero wire in an installation using the three-wire system. With two machines coupled together as these are, it is comparatively easy to obtain their commercial efficiency, and I understood that in this particular case some satisfactory tests have been made.

The Roper Electrical Engineering Company.—The 11-kilowatt dynamo exhibited by this firm is well adapted for manufacturing in quantity. It is a cast-iron machine, and so designed that the magnets and bed-plate are one casting. The advantages of this is that the magnetic circuit has no joints in it, and hence magnetising power is saved. The



Johnson and Phillips' 14-kilowatt Dynamo.

lines. The bushes in the bearings are all made in two halves so as to be adjustable for wear, and there is provision made in all the machines to prevent the oil creeping along the spindle. This is very necessary



to preserve the insulation, and most makers now pay attention to this detail. The two smaller Gramme-wound machines shown coupled together are an example of an equaliser suitable for the three-wire system. They are connected in series across the 200-volt circuit from the large eight-pole dynamo, and the field strengths

magnets are of square section with the edge slightly rounded off, and the poles are so arranged that the former carrying the exciting coil can be slipped on easily. The square contour of the exciting coils has evidently been decided on because it is the most economical form next to the circle, giving a shorter mean length of turn than any other rectangular form. The method used of fitting the pedestals to secure alignment is interesting. The surfaces where the base of the pedestals fit on to the bed-plate are circular, and of the same diameter as the bores of the magnets, and concentric with it. These surfaces on the bed-plate are faced in a boring machine at the same time as the magnets are being bored out. The pedestals are then turned to the same radius, and so perfect alignment and concentricity should be ensured. In theory the method is perfect, but in practice it is not easy to eliminate all spring of the boring shaft or mandrel when one surface only is being cut. The bearings are made long to ensure cool running. The floor space and weight efficiency given on the list for this machine are low. The use of cast iron will account for this to some extent, and if the dynamo is efficient it should find a good demand at the low price for which it can be made.

Laurence, Scott, and Co.—The two-pole dynamo shown by these makers is fitted with the Scott-Sisling system of

armature. It is intended to be used in an installation where accumulators are employed, so as to charge them and light the lamps at the same time. To do this there are two distinct sets of armature conductors and two commutators. The main winding has a sufficient number of turns to give the voltage required on the lamps, and also the full current required from the machine for the lamps. The second winding has much fewer turns, and gives the additional E.M.F. required when charging the accumulators. The two circuits are then connected in series, and the lamp connection is by the same movement switched from battery terminal, on to the junction of the two armature circuits. The two circuits in series then give the voltage required to charge the batteries, while the first commutator still supplies any current necessary for the lamps. The theory is good, but the variable E.M.F. required to charge an accumulator introduces difficulties which cannot be so easily overcome as in the common shunt dynamo, where the potential difference at the terminals rises as the E.M.F. of the batteries rises. This is due to the increase in the strength of the field, and hence the machine can be left without attendance. In this case, if a similar course was adopted, and the machine was simply shunt-wound, the rise in the E.M.F. of the dynamo would occur in equal proportion in both circuits, and hence the lamps would be overrun, so the following precautions and innovations are adopted. The machine is compound wound, and so the current going to the lamps does not disturb the balance, as its demagnetising effect is thus counteracted. Then the extra commutator circuit is joined on at the brush side of the series-turns, so that the batteries can never reverse the polarity of the dynamo. Finally, the second circuit is wound to give the highest extra voltage required to charge the accu-

Laurence, Scott, and Co.'s 11-kilowatt Dynamo.

mulators, and an adjusting resistance is introduced in the main charging circuit, to reduce the current when the charging is first begun. The shunt winding thus always gives a constant exciting power, if the attendant is careful to regulate this resistance. The connection used may seem rather complicated at first sight, but the system will certainly reduce the hours of working the plant, and also save the end batteries from being overcharged, as now often occurs when counter E.M.F. cells are not used. The dynamo is a compact, well-designed machine with a cast-iron magnetic circuit, and a third bearing is introduced to help take the strain of the driving belt.

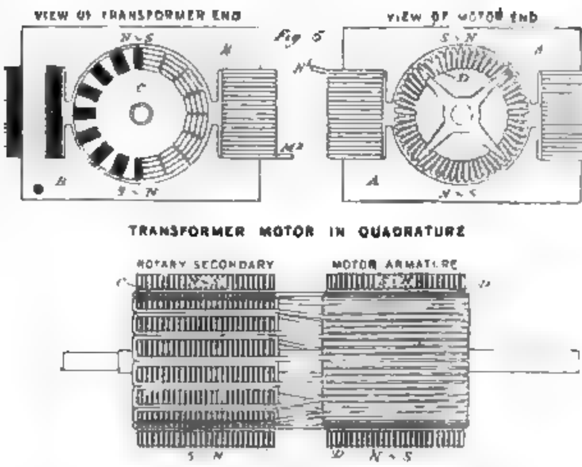
A NEW SYSTEM OF ELECTRICAL DISTRIBUTION AND TRANSMISSION.*

BY RANKIN KENNEDY.

(Concluded from page 425.)

The supply of two alternating currents in quadrature phase is also available for working motors without commutators. Now this is a very important matter. Ordinary motors working with continuous currents, such as the little one on the table, are no doubt very perfect machines and do their work well and economically, but still there are instances in which a motor without a commutator is a very desirable thing to use. One class of commutatorless motor is that known as Tesla's motor, and one known as Prof. Ferraris's motor, and another known as Bradley's motor—any of these motors can be used on this system of alternating currents. These motors are on the same principle, first discovered by Prof. Ferraris, and first enunciated by him. The principle is that known as the rotary polar principle.

A further development of this principle has been shown recently at the Frankfort Exhibition, in which three currents differing in phase by 120deg. are used to work a three-phase rotary polar motor without commutators. I have here before me two models of commutatorless motors, acting on quite different principles from those on which the rotary polar motor acts, and they are expressly designed to work with two currents in quadrature on this new system. The first one, Fig. 5, has two parts—a motor part, A, and a transformer part, B. The motor part consists of a ring or drum armature in a two-pole field; the transformer part has the secondary winding on a drum with radial projections, C, each carrying a secondary coil, the two diametrically opposite secondary coils are joined in series with each other, and with one coil on the ring or drum armature of the motor part, D. The field magnet of the motor part is excited by one of the two currents in quadrature, and the primary magnet of the transformer part is excited by the other current. The primary magnet of the transformer part induces secondary currents in the coils on the radial projections, and these induced currents energise the armature of the motor part, and the motor field is energised by a current in quadrature with that energising the primary magnet of the transformer, so that the magnetic flow may coincide with the phase of the current in the armature of the motor. The motor can now be started to drive a small fan; by a simple reversing key it can be stopped, started, or reversed without the slightest trouble.



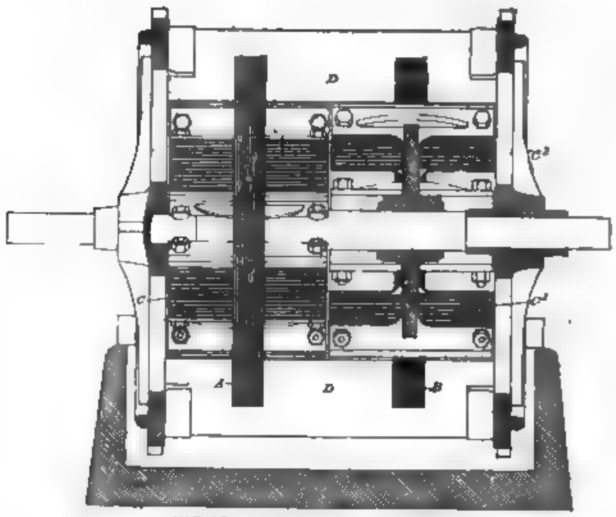
There is no commutator or brushes to attend to. It may be boxed up, only two oil-cups to lubricate two bearings requiring any attention. The other motor without a commutator, Fig. 10, is designed to work with this system. In this motor, as in that last described, induced currents energise the armatures, of which there are two, A and B, each having a separate field magnet, C and D. In its simplest form this model shows the construction of this motor. The fields are two pole-fields, and the armatures are simple Siemens's old H girder shape form, well laminated. The two armatures are at right angles to each other on the shaft. The fields are laminated and excited, one by the one current, and the other by the other current used in this system. Now the action of this arrangement is a little difficult to make clear, although it is very simple. The two fields being separately excited, each by one of the two currents in quadrature, one of them is always at its maximum induction when the other is at its minimum, and the two armatures being at right angles to each other, one of them is in a position to receive the maximum magnetic flow at the instant the other is in a position to receive a minimum magnetic flow. The two armature coils are coupled together to form one closed coil; under these conditions the one armature, which is under maximum induction, generates a current in its coil which also circulates in the coil of the other armature, and the direction of these currents are such as to polarise the armatures in the right direction to cause a torque continually in one direction. In actual working machines the construction is rather different from that of this model. There are more than two poles, and the armatures have also more than two poles, being

* *Paper read before the Institution of Engineers and Shipbuilders in Scotland.*

drums with outward radial projections carrying the energising induction coils. This motor, like the last, has no commutators nor brushes, nor sliding or sparking contacts of any kind; it only requires lubricating at two journals to keep it in perfect order.

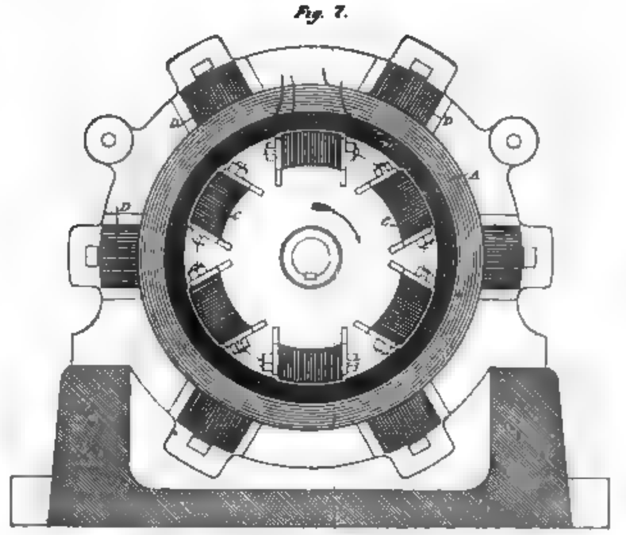
It has now been shown how in this system the electrical energy is sent out to sub-stations at high pressure, and is there transformed down to low pressure, and supplied as a continuous current, or as two pulsating currents, or as two alternating currents in quadrature. You have seen how by two commutators and two transformers the continuous current is derived, and also how the motive power is to be obtained, and the motors for the purpose, both with and without commutators. Having now given a general outline of the system and its chief apparatus, some particulars regarding the generating station and the sub-stations can now be considered. At the generating stations the dynamos generate the two currents in quadrature. The dynamos I have designed for the purpose are shown by Figs. 6, 7, and 9. They are inductor dynamos, having no moving coils, and generate the currents at low pressure and moderately low frequency; a frequency under 40 per second being preferable where alternating currents in quadrature are to be converted into so many different forms. These dynamos require to be double machines in order to enable them to be worked without induction in the exciting coils. The exciting coils on one half are coupled in series with those on the other half, so that the induced E.M.F. in the one opposes the induced E.M.F. in the other, and therefore there can be no current in the exciting coils due to induction. By this construction, it may be interesting to explain, that in these machines the same coils that are used for exciting the machine can be simultaneously used as the generating coils. The copper coils are marked A, B, and the laminated magnets are marked D. The revolving laminated inductors are marked C C′. The generators are low pressure. There is, therefore, no danger in the generating station, and the high-pressure currents to deliver the energy to the sub-stations are raised to high pressure by step-up transformers. The district immediately surrounding the generating station can be best supplied at low pressure direct from the generating station. The high-pressure quadrature currents are carried to the sub-stations on two wires, and have a common return wire. At the sub-stations the high-pressure currents are reduced to low-pressure by two transformers, and converted into continuous current, either wholly or partly. A continuous-current circuit and two quadrature alternating-current circuits may be sent out at low pressure from a sub-station. At some sub-stations only two alternating currents in quadrature would suffice for all the work; at others, the continuous current alone might be sent out; and at others, again, the two pulsating unidirection currents, singly and combined, on a four-wire system, can be sent out from the sub-stations These are matters for judgment, only to be settled for each case under consideration, but all these methods are at the disposal of a supplying corporation adopting this system. Storage batteries can be charged at the sub-stations by the continuous current. If we refer to Figs. 2 and 3, this current pulsates, but never falls below a fixed value. So long as the counter E.M.F. of the storage battery never exceeds this fixed value charging goes on steadily. Fig. 3 shows the arrangement of transformers and commutators for converting the two currents into one continuous current.

Fig 6



INDUCTOR ALTERNATOR QUADRATURE

Fig. 7.



INDUCTOR ALTERNATOR QUADRATURE SECTION

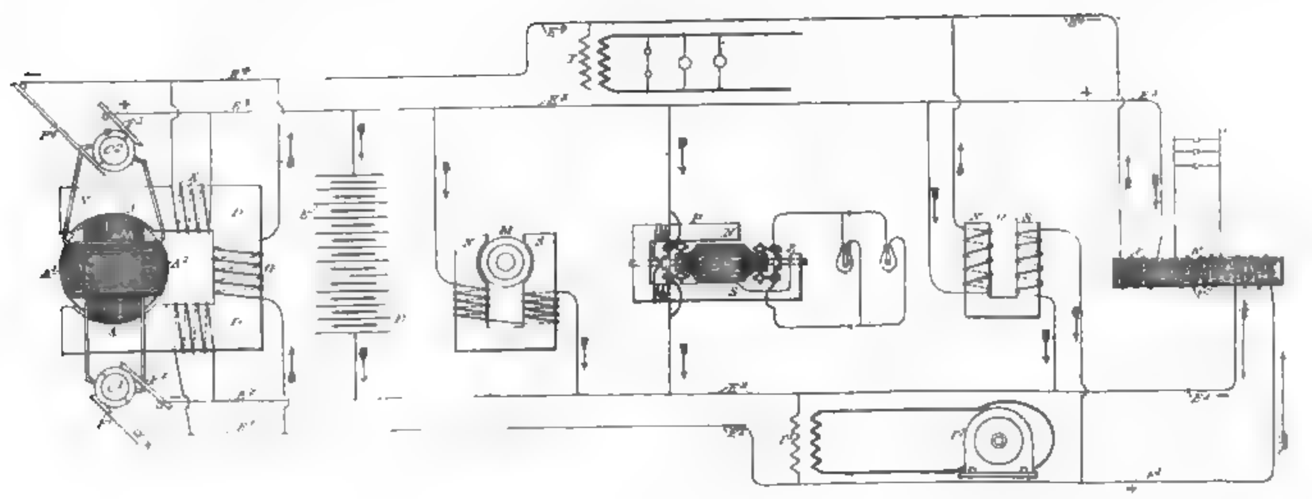
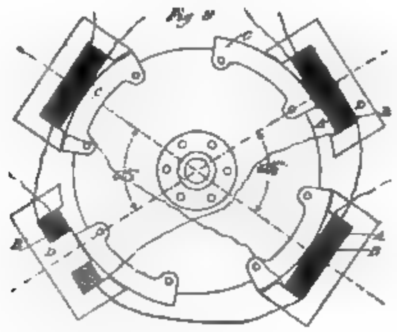


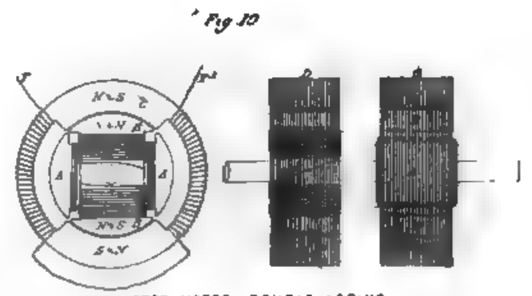
Fig. 8.

There is a method sometimes used for converting alternating currents into continuous currents. In this method there is used an alternating-current motor, driving a continuous-current generator. Such a plan is open to the objection that two very powerful machines are required. If the maximum output is for 1,000 lights, then a motor

of 100 h.p. must be coupled to a generator of 100 h.p. to do the work of conversion. Obviously, this would be a very inefficient combination, especially at under loads. In the method used on the new system a one-horse motor and commutator would convert from 1 h.p. to1,000 h.p. or more. The motor requires power sufficient to drive the commutators only. To apply the system to steamships, where it will be found of vast advantage, only the two alternating currents in quadrature are required, and these are of low pressure—less than 100 volts—so that they are absolutely safe to touch. In modern steamships power is distributed as a rule by steam pipes and small steam engines. In some ships over a dozen small engines are employed for various small power operations, such as pumps, fans, capstans, etc. There is a system of distributing power by water in pipes throughout steamships which has been used to reduce the pressure to a safe limit for working the motors and electric light in the mines. Even the self-starting synchronising motor has this advantage over an ordinary continuous motor in a mine, that after it is started it runs without any attention to the commutators for a long period of time, the commutator being cut out after the start is made. So long as the load on both circuits of the new system is similar and equal, the phase difference is maintained at quadrature. To ensure equality of load, the various consuming devices are always fed from both circuits simultaneously. Two transformers, or one double-wound transformer, is used for producing a single alternating current for lighting purposes, one transformer for each current. The primaries are connected, the one to the one circuit and the other to the other circuit, and the secondaries are connected in series with each other. I



INDUCTOR DYNAMO QUADRATURE



INDUCTOR MOTOR DOUBLE ACTING

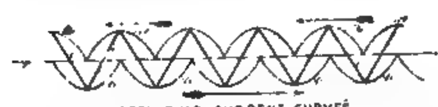
adopted in some steamships—Brown's system in preference to steam. Electrical distribution of power in steamships would have advantages over both, more especially where electric light is now so common on steamers. The same plant can be used for power and lighting purposes. Instead of steam-pipes led all over the ship, wires would be taken from the generator of quadrature alternating currents in the engine-room. And instead of a multiplicity of small, wasteful, and troublesome steam engines, one good compound or triple expansion engine in the engine-room driving the dynamos would do all the work, commutatorless motors being used to drive all the small powers before mentioned throughout the ship.

Motors with commutators would, on account of the attendance required and their liability to get out of order, never be tolerated for power purposes on steamers, but given a commutatorless motor, such as those here shown, there can be no doubt of the success of power distribution in steamships by electricity. The wires transmitting the power throughout a ship are cheaper, less liable to

can show you this arrangement in action. (A Sunbeam lamp worked from two transformers in this way was exhibited.)

Before concluding, it may be well to draw attention to a little difficulty with the working of alternate currents, which, although there is a remedy, is worthy of some attention. Motors, when worked by alternating currents, act as induction coils; they take a large current, but this large current is not in step with the impressed E.M.F., and therefore does not give the watts when it is multiplied by the pressure. This large current is compounded of two currents differing in phase by a quarter of a period; one part of this large current is in step with the pressure, and the other is an exciting current, or magnetising current, which lags a quarter of a period. This lagging current is not produced by the dynamos at the central generating station, but is produced by the self induction of the motors, and is thereby drawn through the dynamos, and is at its

PULSATING CURRENT CURVES



ALTERNATING CURRENT CURVES

ARRANGEMENT OF SUB STATION

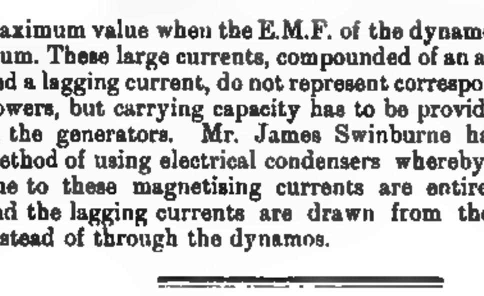


FIG. 11.

accidents, and, if broken, are easily and quickly repaired, and these are all advantages over the steam and hydraulic transmission of power. In mines the very same advantages exist. Most elaborate arrangements have been proposed for boxing in the dangerous commutator to enable a common dynamo to work in mines, one proposal being to choke it in a box of poisonous gases, another to run the brushes inside the commutator. None of these proposals are practicable. The only "perfect cure" is to abolish the commutator altogether in motors for steamships and mines, and thereby get rid of the dangerous sparks, and at the same time enable the motor to run on for long periods with no other attention than that required to fill the lubricators. In steamships high pressures are not required at all; but in mining work high-pressure feeders can be used with a great saving in copper and electrical pressure. A transformer in a cast-iron box, and completely immersed in oil, is then

maximum value when the E.M.F. of the dynamo is at a minimum. These large currents, compounded of an active current and a lagging current, do not represent correspondingly large powers, but carrying capacity has to be provided for them in the generators. Mr. James Swinburne has devised a method of using electrical condensers whereby the troubles due to these magnetising currents are entirely obviated, and the lagging currents are drawn from the condensers instead of through the dynamos.

ELECTRICITY AND THE NAVY.

At the Royal United Service Institution on Wednesday, a paper was read by Lieutenant F. T. Hamilton, R.N., on "Electricity as applied to Torpedo and other Naval Purposes." The paper dealt with recent improvements in various instruments in use, as well

as with the application of electricity to new purposes, and was illustrated by a number of the instruments themselves, the use of which was practically demonstrated by means of a secondary battery of 40 cells, lent by the Electric Power and Storage Company. The last lecture was delivered in May, 1885, by Commander Batten, since which time, said the lecturer, although little had been learnt that was actually new about electricity, great advances had been made in perfecting the methods of application, and the material used became better and cheaper every day, so that its use for naval purposes had become more extended. At one time there was a great tendency to elaborate most intricate machines, but more practical experience had shown that the instruments and machines must be simple, and made in such a way as to stand exposure and rough usage. Taking lighting first, it had become the rule for internal lighting of men-of-war to be by electricity, which was found to be economical, clean, and convenient. A trial had been made of using the hull as a return, but the disadvantage of the increased risk of a breakdown outweighed the economical considerations, so that a complete wire system was now always used. The search-light was now always used, but some preferred a few powerful lights, while others preferred several weaker ones, and a further difference of opinion had arisen as to the elevation of the light. A later modification had been portable lights which could be landed, and be then controlled from the ship. He then touched upon the improvements in secondary batteries, giving the following table with reference to that which he was then using, as compared with the older type made by the same firm :

Type.	Size of plate.	Maximum rate of discharge.	Time of discharge.	Capacity.	Weight of 31-plate cell complete.
		amperes.	hours.	amp.-hours.	lbs.
L (old) ...	9 sq. in.	4	9	36	286
K (new) ..	9 sq. in.	8	3½	28	357

The improvements had therefore given them a stronger and less delicate cell, and one that could be charged and discharged at double the former rate without injury, but they got this at a cost of about 22 per cent. less capacity, and 33 per cent. more weight. The deterioration was now calculated at about 7½ to 15 per cent. per annum. A light and efficient accumulator was a boon they must look forward to yet; with it, steam launches would soon become a thing of the past, and they would be within a measurable distance of the flying machine. Electricity lent itself better than anything else to purposes of telegraphy, although the difficulty was the source of current. The current required should be large, as the larger it was the less delicate the instruments need be; naturally, therefore, secondary batteries had been tried, but by reason of their delicacy and the care required in their use they were not altogether a success. Primary batteries, as being more easily repaired or replaced, had been more largely used, but it was difficult to get great power from them. It was also proposed to work telegraphs with the direct current from the dynamo machine. An instrument of this description had been invented by Mr. Richards, a constructor in the Admiralty. It only took half the amount of current necessary to light one lamp, and that only intermittently, whilst it was in actual motion, and as in our modern ships there was ample dynamo power, there seemed to be no objection to using the dynamo as the source of electricity. This was, however, quite a new departure, and we had not yet got any practical experience of its working. The machine that was at present most commonly in use was the Willis's, and the latest improvement of it, the Willis and Robinson's telegraph. This instrument could be worked either by secondary or by primary batteries. The great point in its favour was that it could not be thrown out of adjustment by being worked too rapidly, as the handle was not in direct connection with the electric mechanism. The fact of putting the handle over wound up, or extended, or compressed a spring, which, in its turn, drove some clockwork; this made the contacts; and no matter how angry or excited the officer of the watch might be, the clockwork would only cause the contacts to be made at a certain slow and deliberate pace, quite fast enough for all practical purposes, but not so fast as to incur any danger of upsetting the adjustments. Another good point was that should this instrument show the wrong indication through the handle being worked when the battery was disconnected for any purpose, or through any other cause, it would re-adjust itself simply by putting the handle hard over. Instruments of this description were used for engine-room telegraphs, helm telegraphs and indicators, and for distance indicators to telegraph the distance of the enemy or target from the officer taking the range to the guns. A large ironclad now being built at the Forges et Chantiers de la Méditerranée was quite the most perfectly fitted ship, electrically speaking, that had ever been built; she had electricity for everything. Among other things she was to be fitted with a most elaborate system of telegraphs for all purposes. Messrs. Elliott were now preparing the instruments; they consisted of engine-room telegraphs, helm telegraphs and indicators, distance indicators and telegraphs, and revolution indicators. These last were very ingenious instruments, invented by Spratt. The fact of pressing a button on the side of the instrument cleared off any former record, and started the clockwork, which went for 15 seconds. On the screw shaft was an electrical contact that was made four times in each revolution; at each contact the instrument indicated one, so that, at the completion of the 15 seconds, the number shown was the number of revolutions the engines were making per minute. A difficulty with respect to logs had always been keeping the revolving contact water-tight; this had now been got over by Granville's log, in which the armour of the vessel became one pole of the battery, and a bar of plumbago on the log the other, the sea-water being the excitant. Another use of the telegraph they were hearing a good deal about at present was for communication with outlying lighthouses and lightships. There were two difficulties in the way: first, that of getting the wire on board the lightships, that must of necessity swing to the wind or tide, or through the surf that was sure to be continually beating on the rocks round an outlying lighthouse. Numerous water-tight swivel contacts had been tried for the lightships—they were more or less satisfactory for a time, but they constantly broke down; and as for the lighthouses, no shore end of cable has yet been made with a sufficiently heavy armouring to stand the action of a heavy surf on rocks for very long. A plan had, however, been patented by the Telegraph Construction and Maintenance Company, by which communication could be made to both lighthouses and lightships without the cable actually going on board them at all. The plan was this: A twin cable was led out from the shore to within about a quarter of a mile of the lighthouse or ship, the cores were then forked out, and ended in large earth-plates about one-quarter of a mile apart, one on either side of the place they wanted to telegraph to. Two earth-plates were put overboard, one from either end of the lightship, or on either side of the lighthouse. If now Morse signals were sent along the twin cable from the shore, using an interrupted current produced by a clockwork sounder, they could be distinctly heard in a telephone on board the lightship. This plan was now under trial, and, he was told, was likely to get over the difficulty of communication. Electricity was very useful for signalling with coloured lights and flashes, and for the latter use special lamps had been made—one containing several very small fibres which rapidly cooled, and the other consisting of a number of fine fibres, each enclosed in a separate bulb, and kept at a dull red heat by a weak current, thus shortening the time required to bring them up to full brilliancy. The addition of a resistance and a condenser also did away with the otherwise excessive sparking of the switch. Another application was for range finding, when two telescopes, as far apart as possible, were mounted on horizontal arcs, divided by thin wire let into insulating materials. Attached to the telescope was a rubbing contact that touched this wire; the telescope pivots were joined together through a battery, and connections were made between the ends of the arcs so that the two portions of each on either side of the telescopes formed the four arms of an electric balance, and between the arms of the balance was placed a galvanometer to indicate by its deflections when and to what extent the balance was disturbed. Now, if these telescopes were moved along the horizontal arc, the resistance that the arc presented to the passage of the electric current was altered, but if the telescopes remained parallel, the resistance in both arcs was altered to the same extent, and the electric balance was undisturbed, and the galvanometer did not move from the zero point, but the telescopes were only parallel when the object to be observed was at an infinite distance. The galvanometer would be marked to correspond to the distances indicated by the different angles at two telescopes. Reference was then made to motors in connection with working the guns and use on boats, of which two samples were given—boats of a type recently built by the Electric Power and Traction Company, at their works near Hampton—one, a pleasure vessel, was a river yacht, 55ft. long and 8ft. 6in. beam. She carried three tons of accumulators and machinery, consisting of 100 accumulators of the B 15 type, having an output of 150 ampere-hours. These cells could be fully charged in five hours, and at the full speed at which the boat was driven they discharged in seven hours, this giving a speed of seven or eight miles an hour, and developed about 5 h.p. A switch close to the steering wheel was so arranged that it could go full or half speed ahead or astern, the difference in speed being obtained by, in the case of full speed, arranging the cells 50 in series and two in parallel, and in the case of half speed, 25 in series and four in parallel. The half speed was about five knots. The propeller made between 700 and 800 revolutions a minute, its pitch being 16in. and diameter 20in. All the accumulators and the motor were either in lockers, forming seats, or under the bottom boards, so that the whole of the boat was available for accommodation. The other boat, presumably for war purposes, was similar to that shown at the Naval Exhibition, and two had been recently sold to the Russian Government. There were two points of advantage in the electrical boat over the steamboat that had not yet been noticed: first, that the former did not require to carry any extra weight, such as coal and fresh water to keep the engines going; and secondly, that the weights in the electric boat could be stowed to better advantage than in the steamboat, as it did not matter where the batteries were placed, so long as they were in the boat; therefore, as they need not be high, they were enabled to build a boat of deeper keel and consequently finer lines. This advantage did not seem to have been made full use of yet; when it was, perhaps they might get rather better comparative results between the two modes of propulsion. With respect to torpedoes, the insulation of the cables was the great difficulty, and what was wanted was to hit off a mean which, whilst giving a small current and therefore light conductor, would not unduly increase the E.M.F. beyond what the insulation of a flexible and light cable was able to stand. In the end it would probably be found that the users of this torpedo would have to rest satisfied with a cable that would be efficient for one or two runs of the torpedo only, but would not stand more use than that. This, of course, meant extra expense—a small matter in war-time.

The paper was followed by a discussion.

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BRADFORD TRAMWAYS.

From time to time brief references have been made to the fact that at Bradford Mr. Holroyd Smith was preparing an experimental electrical tram line, under the auspices of the Town Council, in order to prove that electricity might be substituted for steam. Horse traction for tramways is almost an impossibility at Bradford, and steam is generally used. There is, however, a general desire to get rid of steam if it can be replaced by something with fewer disadvantages. Messrs. Easton and Anderson, the well-known engineers, have carried out the experimental work. The authorities, evidently with the intention of making a crucial test, handed over some 650 yards of tramway just in front of the Midland Station and Hotel, where the gradient averages about 1 in 16, with hardly a trace of level running. It is obviously unfair for us to enter into minute criticism as to the type of motors or gearing adopted for this experimental work. The object of Messrs. Easton and Anderson was to satisfy the authorities that this incline could be safely negotiated under all conditions. If they cannot do that, the temporary installation spells so much lost; if they can, the authorities will, no doubt, be prepared to permanently instal the system over a long length of line—perhaps over their whole system. Thus the truck and machinery of the car used weighs about six tons, and is driven by two double-armature motors and worm gear, with hand-brakes supplementary to the natural motor brake. The current is taken up by a trolley from an overhead conductor, and after going through the motors gets to earth through the wheels and tram rails. The motors can be coupled in series or in multiple. Difficulties have had to be encountered and overcome. The work of putting up the overhead conductor and its connections has had to be mostly done a few hours at a time by night, so as not to interfere with the ordinary running of the tram or the street traffic. The electric car will have for a month to take its place among the running steam trams, and if it performs satisfactorily the authorities will admit the fact as proof of the suitability of electricity generally for tramway work. On Monday last a number of gentlemen were invited to be present at what may be termed a preliminary trial, as the Board of Trade inspectors (General Hutchinson and Major Cardew) were to have the official trial on Tuesday. It is almost needless to say that the car was running during the trials without a hitch. It took the hill with ease, stopped and started as required, was easily controlled in the downward journey, and, when on the downward journey left under the control of the motors themselves, simply started to be stopped, and stopped to be started. In other words, the motors were then driven by the car gravitation movement as generators, and opposed the gravitation movement of the car. Thus directly the car began to move the motors acted and brought it up, then their action stopped and gravitation again acted, and so on. The movement down-hill would therefore be very gradual, and by a series of jerks, if the car were

left wholly under the control of the motors. Desiring to have some indication of the power absorbed while running up the incline, the car was fully loaded with passengers, the total weight of car and passengers being estimated at nine tons, and with this load was run while the instruments at the generating station were watched. The current required is generated at the Bradford central station (described by Mr. Shoolbred in his paper before the Society of Arts, given elsewhere) by two dynamos coupled in series giving 300 volts pressure. It will suffice to say that the maximum current required when loaded as above, and running up the steepest part of the incline, was 70 amperes—say, a total of 28 h.p. There was, and is, and no doubt will be, considerable discussion as to whether the apparatus employed might not be modified and lightened, but at present we have to do with facts, and the facts are broadly as stated. It would have been interesting, no doubt, to have carried out further tests, but under the circumstances of the trial time did not allow of this. Mr. Holroyd Smith and Mr. Courtenay received the visitors on behalf of Messrs. Easton and Anderson, and Mr. Baynes, the electrical engineer of the central station, gave all facilities for seeing the generating plant. The work of the next month will be watched with a vast amount of interest, and assuming, as there is no difficulty in doing, the experiment to be successful, the Bradford Corporation will have the proud and unique position of being both first in the field to supply the electric light and also in adopting and supplying energy from the central station for traction purposes.

TELEPHONY.

We give elsewhere in this issue an article which seems destined to have an history. From internal evidence it may almost be taken as an authoritative statement on behalf of the National Telephone Company. Of course, we have no objection to the National putting forward its view of the case. We have always considered the present state of things as a legacy left by the former management, and to be a state that would probably never have arisen if a broad policy for satisfying subscribers had from the first been followed. Finance and watered capital have proved millstones round the neck of the company, and those who cried out against State monopoly are now crying out against competition. In the manifesto we have the history as seen from the National Company's point of view of its business transactions and connections with the postal telegraph authorities. The Postmasters-General come in for some hard knocks, but then that forms part of their perquisites, and we cannot expect a private company either to acknowledge the Government to be in the right, or that a competing company ought to exist. However, we have always held that two telephone companies cannot satisfactorily exist in the same town. That view remains, but the only way to get rid of incompetent service, of high charges, of an imperfect system, is by open competition. A meeting of "The Association for the Protection of Telephone Subscribers" was held yesterday. The association was formed because of high-handed proceedings of the company, because grievances were pooh-poohed, and because subscribers were paying for services they did not get. The mere existence of such an association shows the wrong policy has been pursued, and though this manifesto may carry conviction to those that require no convincing, it will probably fail to convince men of discernment.

THE METROPOLITAN COMPANY.

The meeting of the Metropolitan Company is held to-day. It will be an important one, inasmuch as more money is wanted. We understand that some severe criticisms have been urged against the balance-sheet, and that it is favourable because it must be so in order to get more money. If it is any consolation to the shareholders or to the investing public to have a companies' finance barometer, we would point out that Messrs. Pender, Anderson, and Co. are always on hand whilst fine weather is likely to prevail, and being behind the scenes, always manage an excuse for leaving when rough weather looms ahead. These gentlemen are keeping up their connection with the company, so it is pretty certain that in their estimation the sailing prospect is fairly satisfactory. Of course, the balance-sheet does not make much of a show as yet, but then time is young, and it certainly is something to be able to say that in a year the lamp connections rose from 48,000 8-c.p. lamps to 82,000, and now has reached 96,000, or double what it was in January, 1891. It may be well to compare the present with last year's accounts in a few particulars. The accounts given last April were for fifteen months, but for comparison we have roughly reduced them to twelve months. Thus the coal bill for 1891 was £10,000, for 1892 it is £13,700 (the nearest hundreds are taken) from which we gather the largest addition to lamps wired was made towards the close of the financial year. Similarly, oil, etc., in 1891 cost £1,760, in 1892 cost £2,560; taking the whole cost of generation, 1891 shows at £17,000, in 1892 at £26,700. Distribution in 1891 cost £48, in 1892 it cost £163; other expenditure in revenue account in 1891 brought the total to £22,000, against £34,000 in 1892. The receipts for the past year, including a payment of £3,027 by the contractors, reached the sum of £43,747, showing a balance over expenditure of £9,719. If we were disposed to be hypercritical, we might suggest that nothing is allowed for depreciation in these accounts, but such criticism would no doubt be met with the assertion that all repairs were paid out of revenue, and the whole plant was kept in the highest possible state of efficiency. A conundrum might be put with regard to one item: When is a loan not a loan? For in one place we are told the amount of loan capital is nil, in another it is £9,606. It may be permissible in early days to make preliminary expenses answerable for a multitude of sins, but in the accounts the amounts should be wiped out as soon as possible. There is just a slight tendency to be querulous over the general balance-sheet. The temporary loan seems very

much as if money had to be borrowed to pay dividends, as it is very similar to net profit. Thus, loan £9,606, profit £9,719. Take away the loan and the cash balance is only £4,600, while the indebtedness is £23,000, against £15,500 to be received. However, the one point of importance is the revenue account. Here, if the distribution of expenses has been properly made, is shown a profit, and with increasing business this should be an increasing profit.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

BIDEFORD LIGHTING.

SIR,—In the current number of the *Electrical Engineer* you have a short note on the public lighting of Bideford.

Some weeks ago there appeared an advertisement in your juvenile contemporary *Lightning*, inviting competitive schemes for an electric light installation, and, probably in common with many others, I wrote to the town clerk asking for further information and details. Receiving no reply, I wrote again about a fortnight later, and was then informed that the time for sending in schemes had lapsed.

I have seen nothing in the technical press since, until your note, which appears to show that some of the inhabitants of Bideford, at all events, are still very much in the dark as to their own town clerk's doings.

Can you kindly inform me:

1. Whether any schemes or tenders were received?
2. If so, who reported upon them, and with what result?

On the face of it, it seems as if the local gas interest had managed things very well for *their* industry.—Yours, etc.,

London, May 2, 1892. SEMPER VIGILANS.

[Our correspondent may find out that the local gas interest has nothing to do with the matter. The contemporary referred to, like other contemporaries, is under the control of electrical engineers, and if the members of the industry imagine that papers so controlled are going to play into other hands—well, they must be very simple. So far as we know, the *Electrical Review* and the *Electrical Engineer* are the only two technical electrical papers not so controlled. None of the other electrical papers hardly dare say "boo" to a goose—in certain proprietary directions.—ED. *E. E.*]

A NEW NAME.

We have received from the Board of Trade a copy of the fourth schedule to provisional orders under the Electric Lighting Acts, and attention is called to the new name which has been given to the unit of supply by the Board of Trade:

"FOURTH SCHEDULE.

"In this schedule the expression 'kelvin' shall mean the energy contained in a current of 1,000 amperes flowing under an E.M.F. of one volt during one hour.

"*Section* 1.—Where the undertakers charge any consumer by the actual amount of energy supplied to him, they shall be entitled to charge him at the following rates per quarter: For any amount up to 20 kelvins, 13s. 4d., and for each kelvin over 20 kelvins, 8d.

"*Section* 2.—Where the undertakers charge any consumer by the electrical quantity contained in the supply given to him, they shall be entitled to charge him according to the rates set forth in Section 1 of this schedule, the amount of energy supplied to him being taken to be the product of such electrical quantity and the declared pressure at the consumer's terminals—that is to say, such a constant pressure at those terminals as may be declared by the undertakers under any regulations made under this order."

TELEPHONY.

April 25, 1892.—The decision of the Exchequer Division of the High Court of Justice in 1880 that the telephone was a telegraph, placed its public use under the control of the Postmaster-General, who granted licenses to the telephone companies of an extremely restricted character, confining the use of telephone exchanges to limited areas around a small selected number of towns, outside which the companies could not give the advantage of the telephone without the special sanction of the Postmaster-General in each individual case. This sanction was never given excepting upon extremely onerous conditions—conditions, indeed, so onerous as to be in most cases prohibitive. Anyone wishing to be a subscriber to an exchange system, say, of five miles radius, who happened to be even a few yards outside of the area, could not be connected with the telephone system within it excepting on condition that his wire should be carried to the central exchange of the system, even though there might be a sub-exchange forming part of the system close to the boundary, and the Post Office, moreover, insisted upon the payment of a higher royalty than that ordinarily charged upon each such special connection, generally from 12½ to 15 per cent. The effect was that although, but for the limitation above described, an ultra-radial subscriber might have been connected with the telephone system by a very short line at the minimum exchange tariff, he had instead, when the system was within, say, a five-mile area, to pay for a connection of over five miles in length to the central exchange, as well as the Post Office royalty of 12½ to 15 per cent., and was consequently placed in an entirely different position to subscribers within the licensed areas. It was, however, arranged, eventually, that a subscriber outside the radius might be connected with the nearest exchange within the telephone area, provided the Postmaster-General was paid his royalty upon such a length of wire as would have been necessary if it had actually been run to the central exchange. It will thus be seen that beyond the favoured areas the Post Office practically deprived the public of the advantageous use of the telephone.

For some time the department refused to allow telephonic communication between the subscribers in the different licensed telephone areas upon any terms, but at last gave way to the extent that it undertook, subject to a special arrangement in each case, to connect certain town areas. The conditions attached to this concession were, that the department should charge a certain rental for each wire, that the company should not allow the use of the wire to more than eight persons; that each person should be charged one-eighth part of the rental of the wire and no more; and that if the number of subscribers was less than eight the company should pay to the Postmaster-General the full rental of the wire. The effect of these conditions was that the company could not gain upon the wire rental from the department under any circumstances, and that, if it could not keep up the full number of subscribers allowed by the department, it must necessarily work this branch of its business at a loss, and, in fact, it mostly resulted in a very heavy loss. Such was the spirit tenaciously maintained by the department in its dealings with the telephone companies, a spirit which could not be approved by any fair and liberal-minded man, until, happily, a statesman of broad views, influenced by a just and liberal animus, became the political head of the Post Office. Mr. Fawcett saw that the system then prevailing deprived the public of the legitimate use of the telephone, placing the inhabitants within and without the licensed areas in entirely different positions, and, in order to place all sections of the population upon a parallel footing, and not to hamper legitimate telephonic enterprise, he arranged with the companies for the issue, in November, 1884, of an entirely new license, which enabled them to exploit the telephone, and to run wires in every part of the country upon the same conditions. He thus abrogated the restrictions inseparable from the plan of licensed areas, and gave the companies power to meet the most manifest public telephonic wants irrespective of regard to locality. After this time the telephone companies proceeded with vigour to build up a business strictly in accordance with the conditions of the

new license, and in which exchange systems in towns and villages, and trunk lines connecting those systems with each other, were inextricably interlaced and conjoined. Finding that the difficulties in the way of a number of companies working the telephone in different large districts, arranging for the proper erection and efficient working of the trunk lines which connected them, and for harmony of management in other respects, were extremely great, and led to delay in perfecting such a system as the public had a right to expect from those who exploited the telephone, it was found expedient to amalgamate the principal telephone companies. This plan of amalgamation, at which the Postmaster-General chose to take offence, was also strictly within the lines of the new license.

The result is that the National Telephone Company, which, with its two subsidiary companies, the Western Counties and South Wales Telephone Company, Limited, and the Telephone Company of Ireland, Limited, does over 90 per cent. of the telephone business of the country, and, taking legitimate advantage of the powers bestowed upon it by the Postmaster-General's license, has put all the principal towns of Scotland, and most of the small ones, into telephonic communication with each other; has connected the industrial districts of England in a similar manner, and is now about to join telephonically the great business centres of England and Scotland, thus putting its subscribers in such a position that they have the power of carrying on important business converse with each other, not only within each industrial town of every business locality, but also of exchanging communications with subscribers in towns far apart from each other. The necessary consequence of this action of the National Telephone Company is that those invited to become subscribers to new telephone companies, finding that they can only communicate with a small number of people in a limited area, and cannot be given the advantage of telephonic communication with outside industrial towns, prefer the wider and greater facilities given by the National Telephone Company. Necessarily these facts give to the National Company, as the result of its enterprise, and of over 12 years of effort, a great and legitimate advantage.

Various rivals have cropped up and have, in common with the Postmaster-General, suffered in their competition with the successful undertaking of the National Telephone Company, having been unable to make satisfactory headway against it. This being the case the department, supported by the Postmaster-General, and apparently in conjunction with the National Company's rivals, has put before the National Company certain proposals involving the absolute surrender by the company of all the conditions of advantage above described—that is to say, of its trunk system and of the strength it derives from the large number of its exchange subscribers. The Postmaster-General requires the National Company not only to sell to the department its trunk system, which would be immediately used for the benefit of all its rivals as well as of itself, but also demands that every telephone company starting in opposition to the National Company, however small, shall be helped in its opposition by the privilege of being able to communicate through the instrumentality of the surrendered trunk lines, with the whole of the National Company's exchange subscribers.

The Postmaster-General thus seeks at one blow to deprive the National Company of the goodwill of a business which is the growth of many years, and to distribute it amongst the company's rivals, including the Post Office itself. He offers the company no equivalent for submission to this levelling and confiscatory process.

To our rivals, who have *no* trunk lines, and who therefore have nothing to surrender, and have either none or but few subscribers, he offers certain wayleaves and other facilities for the conduct of their business, and with a show of impartiality he offers the same facilities to us; but to our rivals he offers an equal share with ourselves in the use of our trunk lines, which he requires us to surrender, and of the advantage of communication with all our over 40,000 subscribers, thus requiring us to aid and stimulate their opposition. To us he gives no relative advantage, but just the same facilities neutralised manifold by what he takes from us. They receive the facilities plus what he deprives us of to give to them. We receive them minus what he would wrench from us to give to them. He offers them prosperity, and he deliberately and of purpose does so at our expense. He professes to propound a scheme that is fair and impartial, but which is so devised that the National Company cannot accept it without grave injury, whilst it gives the National Company's rivals every advantage they could possibly desire. The Postmaster-General, in his speech of the 29th March, having proposed this scheme alike to those it will benefit and those it will injure, tries to force its acceptance upon those who he and the Chancellor of the Exchequer know will be wronged by it, by threatening to withhold wayleaves and other facilities from any company which does not accept the Postmaster-General's entire scheme. The following are the words of the Postmaster-general in the House of Commons: "A new company, with no trunk lines, could not compete with an older company that had trunk lines, (and) whilst the Government proposed that the companies should be allowed, by becoming connected with the Post Office, to achieve a new development in their industry, they only intended to grant the privilege to companies that were ready to join in a system of free and unrestricted communication," so that unless the National Company agrees to assist every opponent by the surrender of its trunk lines, and the advantage in competition it derives from the extent of its enterprise, it will be refused the powers necessary to the proper conduct of its business, which will be given freely to others. It is necessary, therefore, to strip the mask from the pretence of impartiality, under which it is proposed to inflict great injustice. That the Government know full well what is they ask the National Company to give up is shown from the following paragraph from the speech of the Chancellor of the Exchequer: "It is necessary that the Government should take the trunk lines into their hands. If that were not done, they could not have that competition which it was desired they should secure. While the National Company had a monopoly it was impossible for the other lines to compete. A telephone circuit was only half useful unless it was put into telephonic communication with the rest of the country, and unless that were done the people of a locality not in communication with the whole of the country would be only half served, and therefore it was why, in one sense, the Government would have to take the trunk lines into their own hands as a means by which to secure free trade." He stigmatises the advantage which the National Company has gained by its enterprise as a monopoly, in order to cover the insidious policy propounded as a measure of free trade, but the public is the eventual arbiter in such matters, and to public opinion, in case of necessity, we shall appeal.

If the National Company had done that which it was not justified in doing by its license some such policy as that shadowed out in the speeches of Sir James Ferguson and Mr. Goschen might probably receive the support of the public, but as the National Company has most probably endeavoured to make use of its privileges to make the telephone of as much value as possible to the public, there is no justification for the attempt to penalise it with a special view to aid rivals who are acting in harmony with the department. The whole scheme of the Postmaster-General is retrogressive. To carry it out, a distinction will again have to be made between those who use the telephone within given town areas and those who are outside of those areas, to the detriment of the latter, whilst the dual responsibility of the Government and the companies for the joint connection of the telephone exchanges and the trunk system, and the delay that must necessarily arise through having to make connections between the departments and the company's wires each time a trunk call is to be made, must lessen the advantage of the trunk and exchange systems to the community. And all this is sought to be done because the National Company can only be beaten by a combination between the Post Office and the National Company's rivals. With these facts before it, the public will not be surprised should the National Company decide not to surrender its advantages at the bidding of a hostile department, and prefer to combat the department and all-comers, rather than make a weak and cowardly surrender to an unfair and unjustifiable demand.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 429.)

I think it best at this juncture to bring before you a phenomenon, observed by me some time ago, which to the purely

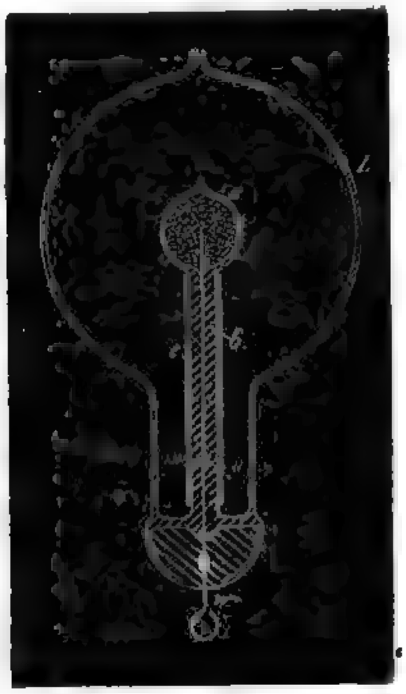


FIG. 12.—Bulb for Producing Rotating Brush.

scientific investigator may perhaps appear more interesting than any of the results which I have the privilege to present to you this evening. It may be quite properly ranked among the brush

FIG. 13.—Bulb for Producing Rotating Brush.

phenomena—in fact, it is a brush formed at, or near, a single terminal in high vacuum. In bulbs provided with a conducting terminal, though it be of aluminium, the brush has but an ephemeral existence, and cannot, unfortunately, be indefinitely preserved in its most sensitive state, even in a bulb devoid of any conducting electrode. In studying the phenomenon, by all means a bulb having no leading-in wire should be used. I have found it best to use bulbs constructed as indicated in Figs. 12 and 13. In Fig. 12 the bulb comprises an incandescent lamp globe, L, in the neck of which is sealed a barometer tube, *b*, the end of which is blown out to form a small sphere, *s*. This sphere should be sealed as closely as possible in the centre of the large globe. Before sealing, a thin tube, *t*, of aluminium sheet may be slipped in the barometer tube, but it is not important to employ it. The small hollow sphere, *s*, is filled with some conducting powder, and a wire, *w*, is cemented in the neck for the purpose of connecting the conducting powder with the generator. The construction shown in Fig. 13 was chosen in order to remove from the brush any conducting body which might possibly affect it. The bulb consists in this case of a lamp globe, L, which has a neck, *n*, provided with a tube, *b*, and small sphere,

FIGS. 14 AND 15.—Forms and Phases of the Rotating Brush.

s, sealed to it, so that two entirely independent compartments are formed, as indicated in the drawing. When the bulb is in use, the neck, *n*, is provided with a tinfoil coating, which is connected to the generator, and acts inductively upon the moderately rarefied and highly conducting gas enclosed in the neck. From there the current passes through the tube, *b*, into the small sphere, *s*, to act by induction upon the gas contained in the globe, L. It is of advantage to make the tube, *t*, very thick, the hole through it very small, and to blow the sphere, *s*, very thin. It is of the greatest importance that the sphere, *s*, be placed in the centre of the globe, L. Figs. 14, 15, and 16 indicate different forms or stages of the brush. Fig. 14 shows the brush as it first appears in a bulb provided with a conducting terminal; but as in such a bulb it very soon disappears—often in a few minutes— I will confine myself to the description of the phenomenon as seen in a bulb without conducting electrode. It is observed under the following conditions: When the globe, L (Figs. 12 and 13), is exhausted to a very high degree, generally the bulb is not excited upon connecting the wire, *w* (Fig. 12), or the tinfoil coating of the bulb, Fig. 13, to the terminal of the induction coil. To excite it, it is usually sufficient to grasp the globe, L, with the hand. An intense phosphorescence then spreads at first over the globe, but soon gives place to a white misty light. Shortly after-

FIG. 16.—Form and Phase of the Rotating Brush.

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

wards one may notice that the luminosity is unevenly distributed in the globe, and after passing the current for some time the bulb appears as in Fig. 15. From this stage the phenomenon will gradually pass to that indicated in Fig. 16, after some minutes, hours, days, or weeks, according how the bulb is worked. Warming the bulb or increasing the potential hastens the transit. When the brush assumes the form indicated in Fig. 16, it may be brought to a state of extreme sensitiveness to electrostatic and magnetic influence. The bulb hanging straight down from a wire, and all objects being remote from it, the approach of the observer at a few paces from the bulb will cause the brush to fly to the opposite side, and if he walks around the bulb it will always keep on the opposite side. It may begin to spin around the terminal long before it reaches that sensitive stage. When it begins to turn around principally, but also before, it is affected by a magnet, and a certain stage it is susceptible to magnetic influence to an astonishing degree. A small permanent magnet, with its poles at a distance of no more than two centimetres, will affect it visibly at a distance of two metres, slowing down or accelerating the rotation according to how it is held relatively to the brush. I think I have observed that at the stage when it is most sensitive to magnetic, it is not most sensitive to electrostatic influence. My explanation is, that the electrostatic attraction between the brush and the glass of the bulb, which retards the rotation, grows much quicker than the magnetic influence when the intensity of the stream is increased. When the bulb hangs with the globe, L, down, the rotation is always clockwise. In the southern hemisphere it would occur in the opposite direction, and on the equator the brush should not turn at all. The rotation may be reversed by a magnet kept at some distance. The brush rotates, seemingly, best when it is at right angles to the lines of force of the earth. It very likely rotates, when at its maximum speed, in synchronism with the alternations, say 10,000 times a second. The rotation can be slowed down or accelerated by the approach or receding of the observer, or any conducting body, but it cannot be reversed by putting the bulb in any position. When it is in the state of the highest sensitiveness, and the potential or frequency be varied, the sensitiveness is rapidly diminished. Changing either of these but little will generally stop the rotation. The sensitiveness is likewise affected by the variations of temperature. To attain great sensitiveness it is necessary to have the small sphere, *s*, in the centre of the globe, L, as otherwise the electrostatic action of the glass of the globe will tend to stop the rotation. The sphere, *s*, should be small and of uniform thickness: any dissymmetry, of course, has the effect to diminish the sensitiveness. The fact that the brush rotates in a definite direction in a permanent magnetic field seems to show that in alternating currents of very high frequency the positive and negative impulses are not equal, but that one always preponderates over the other. Of course this rotation in one direction may be due to the action of two elements of the same current upon each other, or to the action of the field produced by one of the elements upon the other, as in a series motor, without necessarily one impulse being stronger than the other. The fact that the brush turns, as far as I could observe, in any position, would speak for this view. In such case it would turn at any point of the earth's surface. But, on the other hand, it is then hard to explain why a permanent magnet should reverse the rotation, and one must assume the preponderance of impulses of one kind.

As to the causes of the formation of the brush or stream, I think it is due to the electrostatic action of the globe and the dissymmetry of the parts. If the small bulb, *s*, and the globe, L, were perfect concentric spheres, and the glass throughout of the same thickness and quality, I think the brush would not form, as the tendency to pass would be equal on all sides. That the formation of the stream is due to an irregularity is apparent from the fact that it has the tendency to remain in one position, and rotation occurs most generally only when it is brought out of this position by electrostatic or magnetic influence. When in an extremely sensitive state it rests in one position, most curious experiments may be performed with it. For instance, the experimenter may, by selecting a proper position, approach the hand at a certain considerable distance to the bulb, and he may cause the brush to pass off by merely stiffening the muscles of the arm. When it begins to rotate slowly, and the hands are held at a proper distance, it is impossible to make even the slightest motion without producing a visible effect upon the brush. A metal plate connected to the other terminal of the coil affects it at great distance, slowing down the rotation often to one turn a second. I am firmly convinced that such a brush, when we learn how to produce it properly, will prove a valuable aid in the investigation of the nature of the forces acting in an electrostatic or magnetic field. If there is any motion which is measurable going on in the space, such a brush ought to reveal it. It is, so to speak, a beam of light, frictionless, devoid of inertia. I think that it may find practical applications in telegraphy. With such a brush it would be possible to send despatches across the Atlantic, for instance, with any speed, since its sensitiveness may be so great that the slightest changes will affect it. If it were possible to make the stream more intense and very narrow, its deflections could be easily photographed. I have been interested to find whether there is a rotation of the stream itself, or whether there is simply a stress travelling around in the bulb. For this purpose I mounted a light mica fan so that its vanes were in the path of the brush. If the stream itself was rotating, the fan would be spun around. I could produce no distinct rotation of the fan, although I tried the experiment repeatedly; but as the fan exerted a noticeable influence on the stream, and the apparent rotation of the latter was in this case never quite satisfactory, the experiment did not appear to be conclusive. I have been unable to produce the phenomenon with the disruptive discharge coil, although every other of these phenomena can be well produced by it—many, in fact, much better than with coils operated from an alternator. It may be possible to produce the brush by impulses of one direction, or even by a steady potential, in which case it would be still more sensitive to magnetic influence.

In operating an induction coil with rapidly alternating currents, we realise with astonishment, for the first time, the great importance of the relation of capacity, self-induction, and frequency as regards the general result. The effects of capacity are the most striking, for in these experiments, since the self-induction and frequency both are high, the critical capacity is very small, and need be but slightly varied to produce a very considerable change. The experimenter may bring his body in contact with the terminals of the secondary of the coil, or attach to one or both terminals insulated bodies of very small bulk, such as bulbs, and he may produce a considerable rise or fall of potential, and greatly affect the flow of the current through the primary. In the experiment before shown, in which a brush appears at a wire attached to one terminal, and the wire is vibrated when the experimenter brings his insulated body in contact with the other terminal of the coil, the sudden rise of potential was made evident.

I may show you the behaviour of the coil in another manner which possesses a feature of some interest. I have here a little light fan of aluminium sheet, fastened to a needle and arranged to rotate freely in a metal piece screwed to one of the terminals of the coil. When the coil is set to work, the molecules of the air are rhythmically attracted and repelled. As the force with which they are repelled is greater than that with which they are attracted, it results that there is a repulsion exerted on the surfaces of the fan. If the fan were made simply of a metal sheet, the repulsion would be equal on the opposite sides, and would produce no effect. But if one of the opposing surfaces is screened, or if, generally speaking, the bombardment on this side is weakened in some way or other, there remains the repulsion exerted upon the other, and the fan is set in rotation. The screening is best effected by fastening upon one of the opposing sides of the fan insulated conducting coatings, or, if the fan is made in the shape of an ordinary propeller screw, by fastening on one side, and close to it, an insulated metal plate. The static screen may, however, be omitted, and simply a thickness of insulating material fastened to one of the sides of the fan. To show the behaviour of the coil, the fan may be placed upon the terminal and it will readily rotate when the coil is operated by currents of very high frequency. With a steady potential, of course, and even with alternating currents of very low frequency, it would not turn, because of the very slow exchange of air, and consequently smaller bombardment; but in the latter case it might turn if the potential were excessive. With a pin wheel, quite the opposite rule holds good; it rotates best with a steady potential, and the effort is the smaller the higher the frequency. Now it is very easy to adjust the conditions so that the potential is normally not sufficient to turn the fan, but that by connecting the other terminal of the coil with an insulated body it rises to a much greater value, so as to rotate the fan, and it is likewise possible to stop the rotation by connecting to the terminal a body of different size, thereby diminishing the potential. Instead of using the fan in this experiment, we may use the "electric" radiometer with similar effect. But in this case it will be found that the vanes will rotate only at high exhaustion or at ordinary pressures; they will not rotate at moderate pressures, when the air is highly conducting. This curious observation was made conjointly by Prof. Crookes and myself. I attribute the result to the high conductivity of the air, the molecules of which then do not act as independent carriers of electric charges, but act all together as a single conducting body. In such case, of course, if there is any repulsion at all of the molecules from the vanes, it must be very small. It is possible, however, that the result is in part due to the fact that the greater part of the discharge passes from the leading-in wire through the highly-conducting gas, instead of passing off from the conducting vanes. In trying the preceding experiment with the electric radiometer the potential should not exceed a certain limit, as then the electrostatic attraction between the vanes and the glass of the bulb may be so great as to stop the rotation.

(To be continued.)

THE BRADFORD CORPORATION ELECTRICITY SUPPLY.*

BY JAMES N. SHOOLBRED, B.A., M.I.C.E.

In the early part of 1888, the Corporation of Bradford, responding to the expressed desire of a number of their ratepayers, decided to provide a supply of electricity, in accordance with the Bradford Electric Lighting Provisional Order, 1883, for that portion of the centre of the town which had been approved of by the Board of Trade, under the title of the "Compulsory Area" of the order. The preparation of the plans, and the superintendence of the works necessary to carry out the above decision, were entrusted to the author, who, as the consulting electrical engineer of the Corporation, had acted as their technical adviser throughout the earlier stages, while obtaining their provisional order.

* Paper read before the Society of Arts.

After mature and careful consideration, it was decided to adopt the system of continuous current, generated at low pressure, and distributed direct to the houses on the two-wire parallel arrangement (at first, at least), but which could, later on, when the increase in the demand as well as in the distance of the distribution, be so modified as to meet those requirements. In arriving at this decision, it was felt that the "continuous" current offered a number of industrial applications, such as motive power, electro-deposition, storage, and others, peculiarly suited to the needs of a manufacturing town like Bradford; all of which would have been excluded by the selection of the "alternating" current, limited only to lighting. While, again, with the "continuous" current, the use of the secondary battery (not possible with the "alternating" current) afforded, not merely a large reserve of power for use during the night, and at such times of the day when it was also not desirable to run the engines and dynamos owing to the smallness of the demand, but also a most useful regulator acting upon the steadiness of the supply, and counteracting or mitigating any irregularity in the action of the steam engines and other parts of the machinery. The value of such a reserve as the storage battery, in case of any interruption or diminution in efficiency, through the sudden stoppage of any portion of the generating machinery, whether designedly or by accident, can hardly be appreciated.

The financial economy due to the batteries in the working of the generating station is very considerable, since the generating machinery can be completely stopped during many hours of the night and of the day, with a very marked saving in wages, coal, and other similar matters, as against the compulsorily uninterrupted running of the machinery during the entire of the 24 hours, which is imperatively demanded on the "alternating" current system. In the selection of "low pressure" for the distribution of the electric supply, as against "high pressure" (usually, though not necessarily, associated with the "alternating" current) it was felt that the primary duty of a municipal authority was to safeguard the public from as much danger as possible in a matter of this kind, even if such immunity should have to be purchased by the investment of a little more capital in the work (a fact which was extremely doubtful).

In the selection of the generating plant for a central station in the centre of a large town, the important consideration, after efficiency, is probably that of compactness and economy of floor space occupied, as ground is necessarily very valuable in such situation. For this reason it was here determined, after very careful consideration, to adopt a steam engine of the inverted vertical type, driving directly on the same shaft a shunt-wound dynamo, both being placed upon the same bed-plate—an arrangement which allows of as much as 3 h.p. indicated per square foot of floor space being obtained. Nor has this economy in floor space been obtained by a serious increase in the speed of the engines. Of the three engines first laid down, each of 150 h.p. indicated, two (Willans single-acting) have a maximum speed of 280 revolutions per minute (while the third (Marshall's double-acting) does not exceed 180 revolutions. The rate of speed of horizontal engines for the same work would probably have been about 120 revolutions.

Owing to the difficulty of obtaining water for condensing purposes (at a rate of cost which would have been sufficiently reasonable to have effected any economy in fuel), it was decided to make the engines compound and non-condensing, with an initial steam pressure of 120lb. in the steam-chest. It should be borne in mind that with the Willans type of engine, triple expansion can at any time be readily adopted (if water for condensation should become available) by the interposition of a third cylinder between the steam-chest and the present high-pressure cylinder.

The distinguishing feature of the demand for artificial illumination is the very great variation in the amount of that demand, which differs not merely according to the season of the year, but also during each 24 hours, which again may vary considerably according to the conditions of weather which may prevail on any individual day. To endeavour to meet these varying demands, with due regard to economy, where steam is the motive power, it is absolutely necessary to have types of steam engines which are of different producing capacities, so as to ensure that, according to the rate of the demand, a type of a size so proportioned be used such as may be doing a large percentage of its full capacity, and therefore may be working under fairly economical conditions. Bearing this in mind, there have been added later on (as the demand for the supply increased) two other types—namely, two engines of 80 h.p. indicated each, and two also each of 300 h.p. indicated. Furthermore, secondary batteries (which may be looked upon as the equivalent of a 50-h.p. type of steam engine) have also been erected. With these four types (representing dynamos having each a maximum rate of output of 200, 300, 600, and of 1,200 amperes respectively) it will be seen that most of the very varying conditions of the demands for an electric supply can be met under fairly economical conditions.

In order to provide steam for the engines, it was decided to adopt the type known as the Lancashire boiler, which was considered as the most useful and the most economical where steam in large quantities was regularly required. There were first laid down three Lancashire mild-steel boilers, each of 7ft. diameter and 28ft. long, working up to 140lb. pressure per square inch, and nominally of 180 h.p. These have been working very satisfactorily for nearly three years. A fourth similar boiler is now being added, and a Babcock and Wilcox 120 h.p. nominal has recently been fixed. As adjuncts to the boilers, by previously increasing the temperature of the water with which they are fed, there were added later on a feed-water heater, in order to utilise the heat of the waste steam after it had passed from the engines, and then a fuel economiser (Green's) to utilise the heat still remaining in the smoke before it escaped to the chimney. To the above generating plant must be added the various electrical instruments and apparatus of many kinds (such as switchboards, regulating boards with their rheostats) intended for the regulation, measurement, and control of the supply of electricity before it was passed to the town.

All these various apparatus, though each individually partook of the general character implied by its name, were specially adapted to the circumstances of the locality, as well as to the magnitude of the currents to be carried; one distinguishing feature of their arrangement being that all connected with the +, or outgoing mains, were grouped along one side of the engine-room, while all those connected with the −, or return mains, were relegated to the other side of the room—an arrangement which, in the diminution of the chances of accident, has much to recommend it. Of course, the standard instruments for comparing the measurements of other instruments, as well as those for the testing of meters, and many others, were placed apart in the testing-room, as far removed as was practicable from the ever-varying influence of the different masses of iron contained in the engine-room. A further addition to the generating plant in the beginning of 1891, in the form of a secondary battery (Crompton-Howell), composed of a set of 70 67-plate cells (including some reserve ones for testing meters, etc.,) each of 1,000 ampere-hours capacity and with a normal rate of discharge of 200 amperes. This rate of discharge may, however, with this type of secondary battery, be considerably exceeded for a comparatively short period without injury to the cells. In the working of a central station, where a very sudden call in the demand may arise most unexpectedly (through a fog coming on, or from some other cause), the importance of possessing such an elasticity in the maximum limit of the rate of the discharge is very considerable; and it has here proved of grea value on more than one occasion.

In the selection of a type of underground cable, including its protecting covering, which shall comply with the various requirements of an underground main in a town, the following points, amongst many, should be borne in mind (apart from its being an efficient and well-protected conductor of electricity): 1. It should be compact in form and take up little room. 2. It should readily adapt itself to the variations in direction as well as in level, which are constantly demanded from it in crowded thoroughfares by obstacles, such as gas and water mains, house services, cellars, lampposts, etc. 3. It should be readily accessible throughout its entire length, and not merely at certain points, for the connection of house services, as well as for side streets and for testing purposes. All of the above points (and there are many other important ones) should be of much weight; but of them all, probably the last-named (readiness of accessibility throughout the whole of the cable) is of the most practical value in the various street operations which are constantly occurring with a central station supply. After careful consideration, a type of underground armoured cable (resembling, it was afterwards found, that in use in Berlin) was decided upon. It consists of a copper conductor, surrounded by an insulating layer generally, but not always, of a fibrous nature, with a seamless lead casing drawn over it by hydraulic pressure, and with a layer of well-tarred jute or hemp round the lead. Then comes the mechanical protection in the form of two wrought-iron or steel ribbons, each about 1½in. wide, and wound spirally round the cable, the two ribbons breaking joint with each other. Outside is another layer of well-tarred jute, braided and finished off. The total diameter of such a cable would be about 3in., even if the conductor occupied one-third of that length. This cable is laid direct in the ground, the excavation being again filled in with earth. After about 6in. in depth have been filled in, a rough, ordinary deal board is laid down over the cable, to serve as a warning, when encountered by a pick or shovel, that an electric main is underneath. It will be noticed that in this type of cable, the armouring or protection from external injury is carried directly upon the cable, and that at any point in its length this armouring can be cut and removed, in order to make a connection without any detriment to the adjacent parts thereof. All joints with the above-described armoured cables, whether upon the main itself, or for a street branch, or for a house service, are enclosed in a cast-iron case (mostly in an upper and lower half), which, after the joint is made and the whole closed up, can be filled in from the outside with a waterproof composition, so as to make the whole of the interior into a solid mass. The mains are laid, almost without exception, along both sides of the streets under the pavement, thus avoiding breaking into the street itself (where the paving is generally expensive), in order to form the house connections, as would have to be done if a single main only had been laid. Cast-iron street boxes of various kinds to suit the several forms of connections, and placed under the pavement, complete the system of distribution, and afford ready facilities for movable attachments, whereby testing and other operations are much facilitated.

A site belonging to the Corporation and containing about 1,200 square yards, and which is capable of considerable extension, was selected for the central station. Although in the middle of the town, it is outside of the compulsory area selected to be first supplied with electricity. On this ground the necessary buildings were erected. These were larger than was at first required, so as to admit of a considerable increase in the generating plant being placed within them. But these buildings themselves form only a part of a much larger building, which is now in course of construction—so rapid has been the development of the demand for the supply of electricity.

At the time of the commencement of the supply to the public, September 20, 1889, the following generating plant had been installed: Three Lancashire steel boilers, of 180 h.p. each; two

Willans central valve steam engines, each of 150 h.p. indicated, I I type; one Marshall double-acting steam engine, also of 150 h.p. indicated; three Siemens shunt-wound dynamos, each of 120 e.h.p. (150 volts and 600 amperes), each dynamo being coupled to and driven direct by one of the above engines. Also, electrical boards and other apparatus necessary for controlling and regulating the supply to the town. Since that time there have been added: In 1890, one Willans engine of 300 h.p. indicated, I I I type, driving a Siemens dynamo of 240 e.h.p. (150 and 1,200 amperes); and in 1891, another similar Willans-Siemens set, and two sets each consisting of a Willans engine of 80 h.p. indicated, G G type, driving a Siemens dynamo of 60 e.h.p. (150 volts and 300 amperes), as well as a feed-water heater and a fuel economiser. Early in 1891 there was erected the secondary battery of 70 Crompton-Howell cells of 1,000 ampere-hours capacity. As regards the distributing system in the town, while at the commencement of the supply about nine miles of mains were laid in the streets, by the end of 1891 the total length had increased to 18 miles. The motive power, as may be seen from the preceding statement, had about trebled, increasing from 450 i.h.p. to 1,200 i.h.p.; while the maximum rate of nightly output, from 1,400 amperes, at the end of 1889, had increased to a rate of 3,500 amperes at the end of 1801. While the boilers and pipework had been constructed and laid down by Messrs. Holdsworth and Son, of Bradford, and had given every satisfaction, the remainder of the work (exclusive of the secondary battery), but including the steam engines, as well as the entire of the electrical work, both at the station and in the streets, had been supplied by Messrs. Siemens Bros. and Co., Limited; not merely of the original works, but also of the very considerable extensions that followed — proving thereby, in the continued confidence which the Corporation reposed in them, and in Messrs. Willans's engines, how thoroughly and how efficiently the entire of the works had been

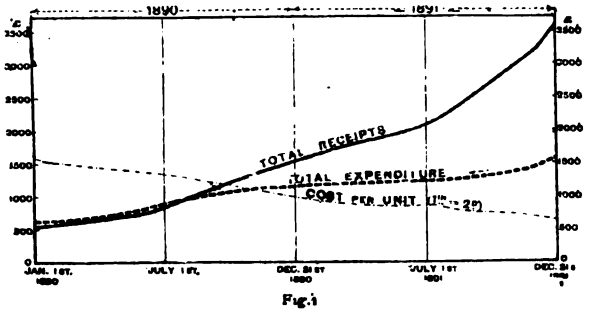


Fig. 1

carried out. The secondary battery was supplied and fixed by Messrs. Crompton and Co., Limited; and it is only fair to say that so far it has given every satisfaction, and that it has proved itself a most valuable aid in the working of the supply of electricity. The buildings, inclusive of their foundations, which are very heavy, owing to a portion of the site being upon the bed of a disused branch of the Leeds and Liverpool Canal, were built in a solid and efficient manner by Mr. W. Johnson, of Bradford; and they have proved, so far, well adapted to their work.

Cost of Working during 1890 and 1891.

The public distribution of the supply of electricity commenced on September 20, 1889, since which date it has been carried on uninterruptedly. But as the working of the installation did not pass into the hands of the Corporation from those of the contractors, Messrs. Siemens, until about two months after, it will be convenient for the purposes of this paper to take the commencement of the regular working as from January 1st, 1890. For the first few months the daily duration of the supply was from an hour before sunset to 11 p.m.; then, owing to a request for an extension of the hours of supply, it commenced at 10 a.m. and lasted till 11 p.m. In February, 1891, the secondary battery already referred to having been fixed, the supply was made uninterrupted throughout the 24 hours; and it has continued so ever since.

It is well known that the nature of the demand for the supply of light (that is, as to the time when it occurs, and as to the duration of such demands) depends very largely upon the character of the district. The one here supplied may be described as a "shop" district, with a few moderate-sized hotels in it, but without any private residences. Latterly, however, these characteristics have been somewhat modified, owing to extensions which have taken place in a neighbourhood where "warehouses" largely prevail—this term in the North of England being applied to a more ambitious building, both in its external appearance and the uses which it is put to, than does a mere receptacle for goods and articles not in actual use; and which does not include an office, nor possibly a resident keeper of the building.

A number of daily curves, some of which are shown in Figs. 3 to 7, illustrate fairly the nature and extent of the lighting during that portion of each of the months selected, both in 1890 and on the corresponding day of 1891. Most of these curves are on a Saturday, which evening was for some time one of the heaviest in the week, but now is one of the smallest in demand (owing to the warehouses above mentioned not being on). There is even now a certain amount of lighting during the day, due to basements of restaurants and of other buildings; this demand, of course, varies with the nature of the weather—if dark, foggy, or otherwise. But there is another source of demand which is beginning to arise—that for motive power, for which a considerable field would appear to exist in Bradford. Where, dependent upon, and resulting from the larger manufactures of the town, are a number of much smaller industries, where mechanical power is needed in quantity ranging from small dimensions up to that of several horse-power, a few of these electric motors have been fixed, some even up to 20 h.p. They are used for hoists, lathes, and various other industrial purposes. Then, again, electroplating, a trade hitherto unknown in the town, has been started in one, if not more, establishments; not to speak of the experiments which the Corporation are trying with the tramways, for the substitution of electricity for the steam power at present in use; horse power being quite inadmissible (except on one line) owing to the very steep inclines, which are constantly occurring—as steep as 1 in 15 (and even more so in one or two cases)—as well as to the great length of the inclines, averaging perhaps 1 in 30 to 40, for over a mile or more, without a counter-gradient to relieve them. It is evident, therefore, that a very considerable demand will before long arise from the causes just enumerated, and that it will, in a great part, be a day demand, and also one which will arise in summer just as well as in winter. What a material advantage, financially, such a demand will be to the present working of the installation (successful, as it undoubtedly has been), a mere inspection of the lighting curves will show. Bearing in mind that this addition comes in to assist the weakest portion of the light curves—the daytime, and in summer, too. A mere glance at the daily curves for the latter part of 1891 will show what an important saving is effected each night by the use of the battery, instead of having to run the engines all night through with so small a load as to be wholly unremunerative.

With respect to the working of the installation, much may be learnt from an examination of Fig. 1, which is a diagram showing the total receipts and the total expenditure of production, distribution, sale, etc. These, the running expenses, do not include interest on borrowed capital and sinking fund for the repayment of the capital, as required by the Local Government Board in the case of corporations. Annexed is the table of the profit and loss account for 1890 and for 1891, which gives in detail the various

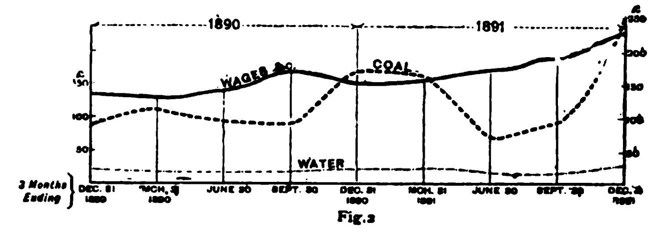


Fig. 2

items referred to in Fig. 1; also the tables of the capital expenditure and of the net revenue account for the same period.

Profit and Loss Account—1890 and 1891.

Expenditure.	Six months ending— June 30, 1890.	Dec. 31, 1890.	June 30, 1891.	Dec. 31, 1891.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Salary and wages...	367 16 8	410 17 10	418 14 3	506 19 0
Coal......	246 17 11	247 0 6	292 18 6	341 15 0
Water..............	33 16 4	34 0 0	34 15 6	36 19 0
Repairs and miscellaneous	100 11 5	204 13 3	266 8 9	431 10 0
Rent of land.........	83 18 2	83 18 1	83 18 1	83 18 1
Rates and taxes ...	46 0 0	104 6 6	67 1 8	69 11 6
Bank interest and commissions.......	19 1 4	89 14 9	95 9 7	120 7 5
Total expenses	898 1 10	1,174 10 11	1,261 5 4	1,591 0 0
Cost per unit sold...	5·51d.	4·10d.	3·56d.	2·47d.
Total receipts.......	858 14 10	1,552 9 9	2,093 13 6	3,592 1 0
Units sold	39,113	68,794	85,103	154,258

Capital Expenditure Account.

	£ s. d.
1889.	
December 31........	18,450 2 4
1890.	
June 30	25,223 19 11
December 31..........	30,464 15 9
1891.	
June 30	35,370 7 11
December 31..................	40,224 19 10

Net Revenue Account.

	£ s. d.	
1889.		
December 31, debit	1,079 8 5	Net loss.
1890.		
June 30, to loss on half-year	732 6 11	
December 31, to loss on half-year	315 6 0	
1891.		
June 30...........	30 5 4	
	2,157 6 8	
December 31, by profit on half-year	971 4 10	Net profit.
	£1,186 1 10	

Inspection of the wages, coal, and water consumption diagram, Fig. 2, as well as the rate of production per unit (excluding interest and sinking fund) will show in what a small ratio these items have

increased, in proportion to the augmentation, both in the electrical output and in the receipts. This is due partly to the fact that the services of the staff have been better utilised latterly than was possible at the commencement. To this result the use of the secondary battery has contributed largely, by allowing the services of the staff to be confined to 12 hours, on an average, mostly during the day hours, instead of being scattered over the entire 24 (as would be the case with an "alternating" current station).

Again, as regards coal and water. Both of these items, the former more especially, have been much reduced of late by the use of the feed-water heater and of the fuel economiser—these taking advantage of the heat (which would otherwise have been thrown away) contained in the waste steam, and in the smoke,

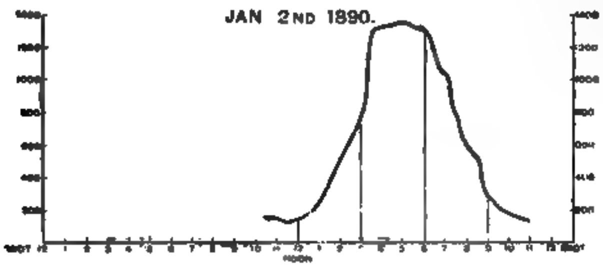


Fig. 3

after it has passed away from the boilers. The economical value of each of these apparatus may be estimated from the following facts: The average temperature of the feed-water to the boiler was when taken from the town supply 55deg. F.; this after passing through the feed-water heater was raised to 180deg.; and this again, when passed through the fuel economiser, was raised to 280deg. before it entered the boilers. By the word "coal" it must not be supposed that anything approaching to "picked steam coal" is meant. The best of the coal used at Bradford would be well described by the word "nuts"; and to this is added, at the boiler, a very large proportion of "slack," or coal-dust of a poor

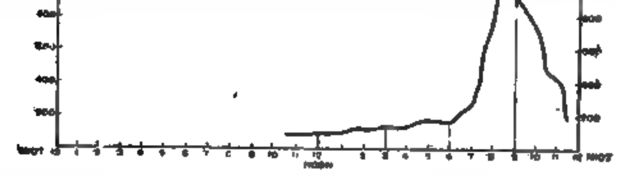


Fig. 4

description, and also of coke, of late—the best coal above used, the "nuts," costing from 8s. to 10s. per ton, according to the market value; while the "slack" costs about half that price. It will be readily seen that engine trials intended to show a consumption of $1\frac{1}{2}$lb. of coal per indicated horse-power per hour, are not made with the above sort of stuff. It should also be borne in mind that the figures given in the table are those of the "gross" coal bills, which include all the fuel required to keep the fires "banked" (during 12 out of the 24 hours), as well as all waste, and also engine trials, etc. While on the question of coal, it may be urged that Bradford, and many other places in the vicinity of coalfields, are in a better position than other towns which are situated farther away from those fields. It may be of some interest to consider what effect this difference in the cost of coal

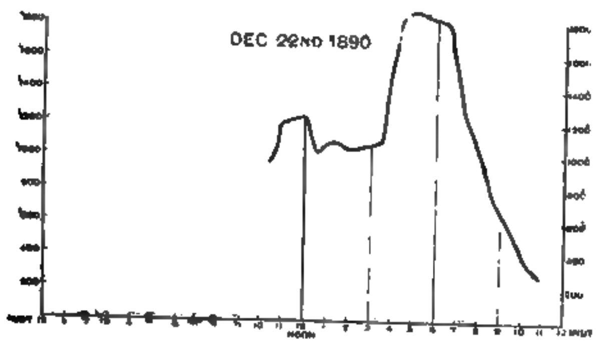


Fig. 5

has upon the expenses, and consequently upon the selling price of the electrical energy at each of such installations. For it may be assumed that the other matters, such as wages, water, oil, etc., remain pretty nearly the same in all large towns. The author has had brought under his notice several places where these differences occur; in some cases engine coal costing about 25s. per ton, or about three times what it does in Bradford. After a careful consideration of such cases, the extra cost in the supply of coal would appear to be met, generally, by the increase of 1d per unit in the selling price. This rough estimate is, moreover, borne out in the case of gas (the manufacture of which is affected in almost precisely the same way). It will be found that the price of gas per 1,000 cubic feet, under similar circumstances, is increased by from 10d. to 1s., or a little over; and, taking roughly the illuminating power for domestic purposes of the electric unit as that of 100 cubic feet of gas, this increase would correspond to the above rate.

In respect of water, however, the town of Bradford has a distinct advantage over many other places. The Corporation supply (which alone is used at these works) is drawn from catchment mountain-basins, situate on a millstone grit formation. It is of a peaty character, with a hardness of from 5deg. to 8deg., and it is admirably suited for use in boilers. It does not, of course, need the use of a "water softener," or of any other expedient, chemical or mechanical, to get rid of the excessive degree of hardness, or of

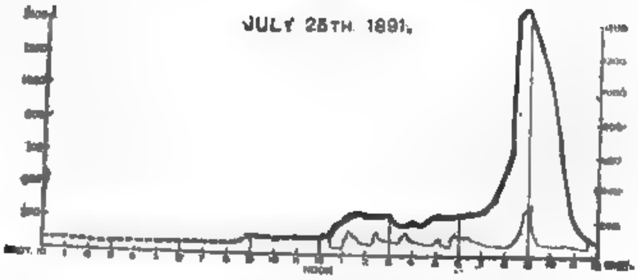


Fig. 6

other of the impurities which prove so detrimental to the well-being, as well as to the duration of boilers.

In conclusion, I have to request the members of the Society of Arts (a society which so faithfully and so thoroughly carries out its title as "The Society for the Encouragement of Arts, Manufactures, and Commerce") to join me in thanking—first, the Corporation of Bradford, not merely for their disinterested action in being the first to take up and solve satisfactorily the question of the public supply of electricity by the local authority, but also for the way in which they have unstintingly and without reserve placed the results of their experience at the disposal of other municipal authorities who may be desirous of carrying out, to the best of their ability, and for the benefit of their respective ratepayers, their duties as regards a public supply of electricity. Next, amongst the various members and officials of the Corporation, I must particularly refer to the chairman of the Gas and Electricity Committee (Alderman Priestman, J.P.), and to the worthy and much-respected town clerk (Mr. W. T. McGowen). Since it is not too much to say that, had it not been for the foresight and business qualities of those two gentlemen, coupled with their firmness and tact in dealing with the many difficulties which, naturally, beset a young and novel undertaking of this kind, it is extremely doubtful whether there would have been any public supply of electricity in Bradford at all, even at the present time. To myself, personally, their kindly support and assistance, ever readily placed at my disposal, has been evinced on so many occasions, that I am unable adequately to do anything more than simply thank them. I must also advert to Mr S. W. Baynes, the

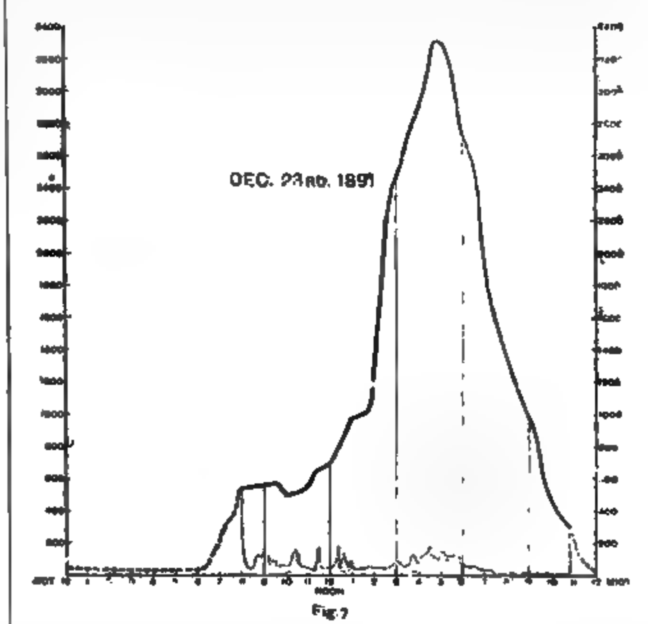


Fig. 7

present resident manager of the installation, and to the ready co-operation which he has always afforded me, not merely in his present position, but also previously while acting as clerk of the works during the construction of the works described in the paper. To his indefatigable energy and good management in the working of the installation is due, very largely, the commercial success which has attended it. My thanks are also due to the several contractors who have been connected with me in carrying out the works. But as by far the largest part of those works, as well as the heaviest responsibility, fell to Messrs. Siemens Bros. and Co., so must I also mention Mr. A. Siemens, of that firm, and his hearty co-operation and assistance ever afforded whenever any

peculiar or novel question presented itself for solution. To the various brother officials of the Corporation of Bradford, as well as to others outside thereof, I would give my best thanks for the kindness and courtesy which I have received at their hands.

Mr. Shoolbred then referred to a value of secondary batteries that must commend itself to all managers of central stations. On February 19th, while the station was working, the fuse of the large dynamo went, and the load was immediately taken up by the battery and the other machines, but principally by the battery. So effectively was this done that no complaints were made by consumers and members of the Corporation who at the time were in committee in a room lighted by the electric light, but did not notice anything out of the ordinary.

During the discussion a number of questions were asked, **Mr. Crompton** wanting to know something about the evaporative power of the boilers, so that comparisons might be made with boilers used elsewhere. **Mr. A. Siemens** gave his opinion in favour of local authorities providing light. **Mr. Willans** supported direct driving as against ropes and belts, and congratulated Mr. Shoolbred on having adopted direct driving. The speaker discussed the difference required by mill work and electrical work, and contended that the former problem was simple compared with the latter. **Mr. Bailey** laid some stress on lamps wired and lamps energised, also on selection of area. **Mr. Reckenzaun** would like details of initial cost. **Mr. Baynes**, the electrical engineer at Bradford, replied to some of the questions, pointing out that the calorific value of the coal used was very low, so that comparisons would be odious; but he gave the figures of 6·84lb. of water evaporated per pound of coal at working pressure, being equivalent to 7·591b. at atmospheric pressure, and that the revenue from the 35-watt lamps worked out at 9s. 7d. per lamp wired; also that the leakage of the system was ·02 ampere, showing a high insulation resistance for a central station. Mr. Albright, Mr. McGowen, and others also took part in the discussion, to which Mr. Shoolbred briefly replied.

COMPANIES' MEETINGS.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY, LIMITED.

The thirty-seventh ordinary general meeting of this Company was held on Wednesday at Winchester House, Sir James Anderson presiding.

In moving the adoption of the report the **Chairman** stated that there had been a decrease of £31,819 in their revenue for the half-year ended December 31 last, as compared with that of the previous six months. He must, however, remind them that the accounts of several of the previous half-years had included abnormally large receipts arising from exceptional causes in South America. With these causes they were well acquainted. The decrease was, however, chiefly owing to the abnormally low rates of exchange which had existed in Brazil during the half-year, and which, he was sorry to say, still continued. There had been an increase in their expenditure of £7,037, of which the bulk was attributable to the additional cost of repairs of cables and to duplexing their newest cable. After paying two interim quarterly dividends at the rate of 6 per cent. per annum, they carried forward £19,893, and he would be disappointed if they did not, as usual, receive a bonus at the end of the financial year payable in October. The current half-year's working was not unsatisfactory. The cables of the Western and Brazilian Company were partly duplicated, but it required the laying of a second cable between Santos and Chuy to provide a complete duplicate system between Great Britain and Buenos Ayres. They had arranged with the Western and Brazilian Company to lay the cable, and they had had a telegram within the last hour saying that the shore end was being landed. He was convinced that the cable would lead to results greatly to their mutual advantage and success in dealing with their competitors. The cost incurred by the Western Company had been very large, and, as the Brazilian Company's fair contribution, they had agreed to pay the Western Company £6,000 per annum instead of making any alteration in the percentages of the joint purse. The Western Company had also given them the right to use their repairing ship for repairs of their cables off the coast of Brazil at a moderate charge per day. In certain cases this arrangement would save the expense of fitting out a steamer in Europe, with a long journey to Brazil and back. Their existing rival on the West Coast of America had forestalled them in securing the Transandine line between Buenos Ayres and Valparaiso, and had so arranged his tariffs as to shut this Company out for the present from any share in the Chilian and Peruvian traffic, but the companies interested in passing this traffic by the East Coast route—namely, the West Coast of America Company, the Western Brazilian Company, and their own Company—were arranging for the construction of an independent Transandine line of improved character between the Atlantic and the Pacific. The Central and South American Company had commenced cutting rates, whereas their own Company had carried out a policy of gradual reductions, as circumstances permitted, ranging from 33 to 50 per cent. of the old rates, according to locality. No doubt they would have continued this policy had not the rival cable project sprung up. They would certainly not remain at a higher tariff than their rivals when the time came to accept the position, and in the meanwhile they were daily watching the course of traffic and safeguarding the shareholders' money and interests. Their second rival was the Antilles cable, but it was certainly not to the interest of that company to reduce tariffs. Of course, they knew what the French Antilles Company were trying to do, but unless that company had Government subsidies, it did not appear to him that they were in an enviable position; but still they might have to count with the opposition of that company by-and-by. They had now a third rival in the South American Cable Company, which had just been brought before the public. That company propose to unite Africa with Brazil by a cable between Senegal and Pernambuco, and so provide another route to Europe *viâ* Africa. He might remind them that Africa was already joined to Brazil, and the route to Europe was already in existence, as the Brazilian Submarine Company's cables at St. Vincent were in connection with that of the African Direct Telegraph Company, and, in fact, with the whole world. He did not think he would have felt it his duty to say anything against the new company whatever he might have thought, because contractors had a right to keep their machinery going if the public would find the money, or if they were rich enough to risk their own money; but in their prospectus they held the Brazilian Submarine Company up as one they intended to injure. They had also based their estimates of revenue on a few exceptional years, when civil war by sea and land, revolution, and financial crisis caused reckless telegraphing and expenditure, which naturally inflated this Company's receipts at a time when every other means of communication with the outer world than by their East Coast cables was stopped. The new company in their prospectus assumed that they might reasonably expect to take from this Company £85,000 per annum of such extraordinary receipts, which, however, had, since the advent of peace, already diminished by one-third. The tariffs were reduced and were certain to be still more reduced, while the loss by exchange on the charges collected in Brazil was equivalent to another very large reduction. They gave data in their prospectus which he could assure them would prove disappointing. The new company was, however, formed, the ship had sailed with its cable, and they would have to meet its opposition; but the Directors were not in any despondent mood, though, of course, they were anxious. Their entire system was duplicated, and the newer cable was duplexed, giving practically, the carrying capacity of three cables; and the duplication of the cables of their partners, the Western and Brazilian Company, between their point of landing at Pernambuco and the River Plate, was completed and the duplex working between London and the River Plate would now be arranged for. Their traffic was being transmitted with great speed, which they were improving every month. They had duplicated their cables without increasing their capital, and they had a substantial available reserve for extensions of contingencies. Their receipts from the West Coast of Africa and the Cape colonies were of considerable importance, whereas their rival's calculation was as if all the Company's revenue resulted from the traffic between Pernambuco and Europe. They would also soon have a direct line across the Andes to Chili, and all the way to Lima—in fact, a complete thorough communication from Peru and Chili to Great Britain and Europe. Nothing that forethought or a judicious expenditure of their money could have done to strengthen their position had, in his opinion, been neglected.

The **Hon. W. St. John F. Brodrick, M.P.**, seconded the motion.

The **Chairman**, in answer to questions, stated that the cost of the Transandine line would be about £100,000, or perhaps £120,000, and it would be carried out by debentures, he assumed, with a little capital if necessary. The three companies would be united in making the line. This Company's proportion of the cost would be one-half, but he did not expect any loss upon the outlay—in fact, he rather thought it would be a good investment. It was expected by the South American Company that their cable would be open for traffic in July next. A project was now being discussed in Lisbon to give both their Company and the Eastern Company an extension of their monopoly for 10 years if they would connect with the Azores. He did not know whether they would get the work, as the French company were striving hard in the same direction. If the Brazilian Submarine Company succeeded it would cost them £50,000, but they would have a splendid monopoly.

The motion was adopted.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY, LIMITED.

The thirty-seventh ordinary general meeting of this Company was held on Wednesday at Winchester House.

Sir John Pender, who presided, stated that the gross receipts for the half-year ended December 31 last had been £243,658, showing a decrease compared with those for the corresponding period of 1890, of £35,437, of which nearly £12,000 was due to fluctuations in exchange, £14,000 to the reduced rates to Australia, and the balance to the commercial depression which had prevailed in the far East for some time past. The working expenses had been practically the same as during the corresponding period of 1890. Comparing the figures for the whole year, the gross receipts for 1891 had been £508,536, a decrease of £25,415 on those of 1890, while the net revenue for 1891 had been £289,522, or a net decrease for the year of £13,960. The usual interim dividends had been distributed during the past year, making, with the dividend now proposed to be paid, a total of 5 per cent. for the year; and it was also proposed to pay a bonus of 4s. a share, or 2 per cent., making a total distribution of 7 per cent. for the past year. The balance of £111,987 had been carried to the general reserve fund, which now stood at £428,842, after charging it with

£194,937 during the year for the balance of the cost of the Madras-Penang (duplicate) cable, the balance of the cost of the partial renewal of the Hong Kong-Tonquin and the Madras-Penang (original) cables, and for the cost of the Penang-Sumatra cable. Since the issue of their report they had completed another month's working under the guarantee arrangement made with certain of the Australasian Governments for testing the effect of a 4s. rate to Australia, and they were consequently in a position to give the figures for the full year of the experiment. The number of words transmitted during the year had increased 50 per cent. over that of the corresponding period of 1890-1891, and 6½ per per cent over that of 1889, the year adopted as the basis of the guarantee, while the receipts had diminished to the extent of £55,040. One-half of this loss was borne by the guaranteeing colonies and the other half by the associated companies and the Indo-European department of her Majesty's Indian Government, this Company's proportion being £17,770, and that of the Eastern Company £7,862. As the Directors never expected that the entire loss would be recouped during the first year, they were not disappointed with the result, and had agreed to the experiment being continued for at least another year. Negotiations were proceeding with the Spanish Government for the duplication of the cable between Hong Kong and Cape Bolinao. An arrangement had also been entered into for the manufacture and laying, on account of the Netherlands-Indian Government, of a cable to connect Acheen with the Company's new line at Sumatra, and the Telegraph Construction and Maintenance Company's steamer, "Seine," would this week leave the Thames with the requisite cable on board to execute this work. As to the staff pension fund, the Directors had had a scheme prepared by experienced actuaries, who had advised that an annual contribution of 2½ per cent. on the salaries, and a similar contribution by the staff, would, if invested at 4 per cent. compound interest, provide sufficient funds to make adequate retiring allowances for the younger members of the staff on their attaining sixty years of age, but as many of the older employés had already seen considerable service, and their retirement in some cases would not be far distant, 2½ per cent. would be insufficient to place them on an equally favourable footing. With a view, therefore, to supplementing their allowances from the pension fund, the actuaries advised that, in addition to the 2½ per cent. referred to, the Company should continue their present contribution to the endowment assurance fund in full until all the existing policies were paid off, and allow the savings effected by the premiums ceasing to be payable to the assurance company as the policies matured from time to time to be applied exclusively for the benefit of the older servants. They further recommended that the Company should guarantee 4 per cent. interest on the accumulations of the fund. He concluded by moving the adoption of the report and the payment of the dividend and bonus recommended.

The **Marquis of Tweeddale** seconded the motion, which was carried.

The **Chairman** afterwards proposed, and **Sir James Anderson** seconded, a resolution approving the establishment of a staff pension fund, and authorising the Directors to carry out the same upon such terms and conditions as they might think expedient.

The motion was unanimously carried.

COMPANIES' REPORTS.

METROPOLITAN ELECTRIC SUPPLY COMPANY, LIMITED.

Directors: Sir John Pender, K.C.M.G. (chairman); J. Denison Pender, Esq. (deputy chairman); Sir George Elliot, Bart., M.P.; Admiral of the Fleet Lord John Hay, G.C.B.; Admiral Sir George H. Richards, K.C.B., F.R.S.; Sir James Anderson; J. Spencer Balfour, Esq., M.P.; J. C. Parkinson, Esq., John B. Verity, Esq., H. Granville Wright, Esq. Secretary: E. Cunliffe-Owen, Esq., C.M.G. Manager: E. S. Claremont, Esq. Chief engineer; Frank Bailey, Esq., A.M.I.C.E. Consulting engineers: The Lord Kelvin, D.C.L., Pres R.S.; Dr. John Hopkinson, F.R.S.; Prof. George Forbes, F.R.S.

Report and accounts of the Directors to be presented to the fifth ordinary general meeting, to be held at Winchester House, on Friday, the 6th May, 1892, at 12 o'clock.

The Directors submit a statement of the Company's accounts for the year ending the 31st December, 1891, prepared in the form prescribed by the Board of Trade, under the provisions of the Electric Lighting Acts of 1882 and 1888. During the year the Company has been steadily extending its system of underground cables, and except in certain of the outlying portions of the Company's areas, all the more important thoroughfares are provided with mains. The Directors are pleased to report that all the Company's stations have worked satisfactorily. The generating station for the Paddington district, which has been in course of construction during the past few months, will be completed almost immediately. The expenditure upon the works of construction during the year has been £113,580, making a total capital expenditure to the 31st December, 1891, of £486,926. This practically absorbs the Company's capital. Additional capital is required for the completion and equipment of the Paddington installation, supplying a wealthy and important district which the Company has been successful in securing since its incorporation. Provision may also have to be made for certain street lighting, and other contemplated extensions of supply. The Board propose to meet the outlay for these purposes by a debenture issue not exceeding £100,000. The terms of such issue are now under the consideration of the Board, and the debentures will be offered in the first instance to the shareholders. The gross revenue for the year amounted to £43,747. 1s. 3d., including a sum of £3,027. 1s. 3d., paid by the contractors on account of expenditure incurred by the Company in working the Sardinia-street, Rathbone-place, and Manchester-square installations during the time of testing, etc. The net revenue for the year was £9,719. 10s. 8d., which enables the Directors to recommend a further final dividend of 2s. per share. The Company's lamp connection, which on January 1, 1891, was equivalent to 48,000 8-c.p. lamps, rose during the year to 82,000 lamps. It now amounts to 96,000 lamps, and continues steadily to increase. With this increase the percentage of net profit may be expected to grow rapidly, as there will be no corresponding increase in the fixed charges. It is with much regret that the Board have to record the death of their colleague, Alderman Sir R. N. Fowler, Bart, M.P. The vacancy thus caused has been filled up by the appointment of Admiral of the Fleet Lord John Hay, G.C.B. In accordance with the articles of association, the following Directors—viz, J. Denison Pender, Esq., Admiral Sir George H. Richards, K.C.B, and John Benjamin Verity, Esq.—retire from the Board, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., retire, and offer themselves for re-election.

CAPITAL ACCOUNT YEAR ENDING DECEMBER 31, 1891.

Dr.	Expenditure to Dec. 31, 1890. £	s.	d.	Expended during the year. £	s.	d.	Total expenditure to Dec. 31, 1891. £	s.	d.
Lands, including law charges incidental to acquisition	12,365	8	9	23	10	0	12,388	18	9
Buildings	89,271	15	7	35,738	5	4	125,010	0	11
Machinery	129,730	15	8	19,729	7	10	149,460	3	6
Accumulators at generating and distributing stations	6,126	3	9	49	5	2	6,175	8	11
Mains, including cost of laying the mains	63,412	6	8	42,781	0	6	106,193	7	2
Transformers, motors, etc.,	24,618	17	7	11,612	15	3	36,231	12	10
Meters, and fees for certifying under the Act	4,083	9	11	1,315	10	0	5,398	19	11
Electrical instruments, etc.	583	11	4	391	3	5	974	14	9
Station fittings (cable, mains, lamps in stations)	663	4	10	822	14	10	1,485	19	8
Purchase of patents or patent rights	—						—		
Cost of licenses, provisional orders, etc.	6,880	5	2	478	4	0	7,358	9	2
Expenditure on offices, including furniture at offices, stations, etc.	1,716	1	1	638	9	1	2,354	10	2
Proportion of management and general expenditure, chargeable to capital—viz., engineer's department, including consulting engineers, maps, plans, etc.	7,939	7	0	2,781	14	7	10,721	1	7
Law and accountant's charges	836	0	4	255	11	1	1,091	11	5
Rent, rate and taxes, salaries, Directors' fees, and other expenses......	15,658	15	10	6,422	12	3	22,081	8	1
	363,886	3	6	123,040	3	4	486,926	6	10
To balance							10,560	2	2
							£497,486	9	0

Cr.	Receipts to Dec. 31, 1890. £	s.	d.	Received during year. £	s.	d.	Total receipts to Dec. 31, 1891 £	s.	d
Ordinary shares of £10 each	367,016	9	0	129,470	0	0	496,486	9	0
Founders' shares of £10 each	1,000	0	0	—			1,000	0	0
	368,016	9	0	129,470	0	0	497,486	9	0
							£497,486	9	0

REVENUE ACCOUNT FOR THE YEAR ENDING DEC. 31, 1891.

	£	s.	d.	£	s.	d.
A.—To Generation of Electricity.						
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works	13,732	9	0			
Oil, waste, water, and engine-room stores	2,558	16	0			
Proportion of salaries of engineers, superintendents, and officers..... ...	1,762	3	4			
Wages and allowances at generating stations	5,402	7	1			
Repairs and maintenance as follows—Buildings, £92. 11s. 2d.; engines, boilers, £2,054. 0s. 7d.; dynamos and exciters, transformers, motors, etc., £112. 7s. 7d.; other machinery, instruments and tools £847. 10s. 10d.; accumulators and accessories, £132. 9s	3,238	19	2			
				26,694	14	7

B.—To Distribution of Electricity.

	£	s.	d.	£	s.	d.
Repairs, maintenance, and renewals of mains of all classes, including materials and laying the same.....	35	11	9			
Repairs, maintenance, and renewals of transformers, meters, and other apparatus on consumers' premises	74	11	0			
Pole rents and wayleaves	53	3	0			
				163	5	9

C.—To Proportion of Rents, Rates, and Taxes.

	£	s.	d.	£	s.	d.
Rents payable .... } Rates and taxes . ... }				2,644	6	3

D.—To Proportion of Management Expenses.

	£	s.	d.	£	s.	d.
Directors' remuneration....	850	0	0			
Salaries of management, secretary, engineers, accountants, clerks, and messengers..	1,846	1	11			
Wages of meter readers and wiring inspectors	313	4	7			
Commission to canvassers	9	12	0			
Stationery, printing, and agreements	219	14	5			
General establishment charges.........	724	13	7			
Auditor	52	10	7			
				4,015	16	6

E.—To Proportion of Law and Parliamentary Charges.

	£	s.	d.	£	s.	d.
Law expenses				40	9	8

F.—To Special Charges.

	£	s.	d.	£	s.	d.
Insurances.........				468	17	10
Total expenditure..				34,027	10	7
Balance carried to net revenue				9,719	10	8
				£43,747	1	3

Cr.	£	s.	d.	£	s.	d.
Sale of current per meter at 7½d. per B.T.U.	22,683	0	10			
Sale under contracts	15,084	8	3			
				37,767	9	1
Rental of meters and other apparatus on consumers' premises				1,816	19	11
Rents receivable				544	3	10
Transfer fees				57	9	6
Special items: Net proceeds of work done for and goods supplied to sundry consumers.. . ..				533	17	8
Amount allowed by contractors on account of running expenses during completion and starting of stations, in lieu of coal, oil, water, etc., consumed during erection and testing of installations				3,027	1	3
				£43,747	1	3

Dr. NET REVENUE ACCOUNT, DEC. 31, 1891.	£	s.	d.
Bank charges and commission	16	6	6
Interest account	157	1	10
Allowances to electric light consumers	191	14	3
Bad debts	187	16	0
Interim dividend of 2s. per share, paid 1st May, 1891......	4,706	0	8
Balance applicable to dividend on ordinary stock or shares	5,454	19	10
	£10,715	19	1

Cr.	£	s.	d.
Balance brought from last account	461	10	2
Balance brought from revenue account	9,719	10	8
Discounts	534	18	3
	£10,715	19	1

Dr. GENERAL BALANCE-SHEET, DEC 31, 1891.	£	s.	d.
Amount received as per capital account .	497,486	9	0
Temporary loans	9,606	14	3
Sundry tradesmen and others due on construction of plant and machinery, fuel, stores, etc. ..	21,868	2	5
Sundry creditors on open accounts	788	1	3
Net revenue account: balance at credit thereof .	5,454	19	10
	£535,224	6	9

Cr.	£	s.	d.	£	s.	d.
Amount expended for works as per capital account				486,926	6	10
Stores on hand—						
Coal	£525	6	0			
Oils, waste, etc.	82	13	0			
General........	4,435	17	11			
				5,043	16	11
Sundry debtors for amounts paid on account of contracts in course of completion				2,643	5	5
Preliminary expenses				5,052	10	4
Sundry debtors for current supplied				14,314	13	11
Other debtors				1,141	19	9
Deposits (provisional orders, vestries, etc.)				5,912	10	6
Cash at bankers:						
Messrs. Prescott, Dimsdale, and Co.	£1,663	10	1			
The Royal Bank of Scotland.	12,519	14	3			
				14,183	4	4
Cash in hand				5	18	9
				£535,224	6	9

WESTERN AND BRAZILIAN TELEGRAPH COMPANY, LIMITED.

The report of the Directors of this Company for the half-year ended December 31 states that the total earnings amounted to £92,345, a decrease of £16,472. In common with other South American undertakings the loss on exchange was heavy, and in this Company's case reached the large sum of £19,133. But for this loss the revenue would, it is stated, have been in excess of that for the corresponding period. The working expenses amounted to £38,404, an increase of £1,204. Including the amount brought forward and the dividend received upon the shares held in the Platino Company, the revenue balance is £67,798, from which has been deducted £12,807 for debenture interest and £6,293 for the debenture redemption fund, leaving £48,698, of which £15,000 has been placed to the reserve fund. The Directors recommend a dividend of 6s. per share, tax free, for the half-year on the ordinary shares, making, with the dividend paid in November last, 4 per cent. for the year, leaving a balance of £4,486 to be carried forward. In the case of shares which have been divided into preferred and deferred, 1s. 6d. per share of the dividend now recommended will be payable to the preferred shareholders, and 4s. 6d. per share to the deferred shareholders. The third annual drawing of the A and B debentures took place at the offices on January 15 last, in the presence of Mr. W. W. Venn, jun., notary, when debentures amounting to £12,700 were drawn, and have since been paid off at par. Under a satisfactory arrangement with the Brazilian Submarine Telegraph Company, a contract for the immediate duplication of the Company's lines between Santos and Chuy has been entered into with the Telegraph Construction and Maintenance Company, Limited, and the expedition to lay the cable is now on its way out. Upon the completion of this additional line, and in consideration thereof, this Company will receive a payment of £6,000 per annum from the Brazilian Submarine Telegraph Company. When this cable is laid, the lines of the Company will be duplicated over the whole of the busy part of the system—namely, from Pernambuco to Montevideo, thus affording, in connection with the through lines working in concert with this Company, duplicate lines from Europe to Brazil, Uruguay, and the Argentine Republic. The new cables will be duplexed throughout.

NEW COMPANIES REGISTERED.

Waverley, Limited.—Registered by Allen and Edwards, 5 and 6, Great Winchester-street, E.C., with a capital of £75,000 in £1 shares. Object: to acquire the patent rights, business, and goodwill of Edward S. Higgins and H. C. Jenkins, and also an invention relating to improvements in typewriters, and to develop and turn to account the same in such manner as the Company may deem expedient; also to carry on business as mechanical and electrical engineers, stationers, etc. The first subscribers are:

	Shares.
A. W. G. Ranger, 17, Fenchurch-street, E.C.	1
E. S. Higgins, 6, Thorburn-square, Surrey	1
F. Allen, Warrington House, Duppas-hill, Croydon	1
H. C. Jenkins, 99, Iverson-road, Hampstead	1
J. N. Dauncey, 207, Brixton-road, S.W.	1
J. Allen, Suffolk House, Duppas-hill, Croydon	1
H. Allen, Warrington House, Duppas-hill, Croydon	1

There shall not be less than three nor more than five Directors. The first are A. W. G. Ranger, E. S. Higgins, H. C. Jenkins, and F. Allen. Qualification: 500 shares. Remuneration: Managing Director, £750 per annum, with an additional £50 for each 1 per cent. after payment of 10 per cent. dividend; Chairman, £150; ordinary Directors, £100 per annum each, with an additional £25 for each 1 per cent. after payment of 10 per cent. dividend.

Western Counties Electric Light and Power Syndicate, Limited.—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £25,000 in £50 shares. Object: to acquire the undertaking of electrical engineers now carried on by G. Parfitt and Son, at Keynsham, Somerset, in accordance with an agreement, made April 22, between G. J. Parfitt and T. J. Parfitt of the one part, and S. F. Andrews, on behalf of this Company, of the other part, and generally to develop and extend the same. Subject to certain modifications, the regulations contained in Table A apply.

BUSINESS NOTES.

The Companhia Brazileira de Electricidade has decided to liquidate

West India and Panama Telegraph Company.—The receipts for the half-month ended April 30 were £2,669, against £2,984.

Cuba Submarine Telegraph Company.—The receipts for the month of April were £60 less than for the corresponding month.

Eastern Telegraph Company.—The receipts for the month of April were £53,683, as against £60,909 for the corresponding period.

Direct Spanish Telegraph Company.—The receipts for the month of April were £1,785, as against £1,825 for the corresponding period.

Western and Brazilian Telegraph Company.—The receipts for the week ending April 29, after deducting 17 per cent. of the

gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,275.

City and South London Railway.—The receipts for the week ending May 1 were £794, against £733 for the same period of last year, or an increase of £61. The total receipts to date from January 1, 1892, show an increase of £1,171, as compared with last year.

Islington General Electric Supply.—A petition is to be heard before Mr. Justice Chitty to-morrow for confirming a special resolution reducing the capital of the above-named Company. We are glad to see that one clause of the resolution is to reduce the capital of the Company by cancelling the founders' shares.

Submarine Cables Trust.—The report for the financial year to April 15 states that the revenue, including £2,636 brought from the previous accounts, amounted to £25,436. During the year coupons were met and paid as follows: £1 on account, May 15, 1891; £2 balance, October 15, 1891; £3 paid March 15, 1892; and £1. 2s. 6d. payable April 16, 1892. The expenses of the trust amounted to £1,186, and the payments on account of the coupons to £24,089, leaving £159 to be carried forward.

Great Northern Telegraph Company of Copenhagen.—The report for the year 1891 states that the traffic receipts were most satisfactory during the first six months of the year, but the tariff reductions fixed by the International Telegraph Conference at Paris coming into force on July 1st, there was a marked falling off in the receipts for the rest of the year. Notwithstanding this, the gross receipts were a little higher and the expenses somewhat lower than in 1890. The Board recommended that the total dividend should be fixed at the same figure as last year—17s. 2d. per £10 share, or about 8·60 per cent.

Electric Light Investments.—The following is a list of dividend-paying shares in electric companies, together with their yield at present prices. Most of the shares are fully-paid; but where they are not, the full amount of the shares is inserted in parentheses:

Name of company.	Amount paid up.	Latest price.	Last dividend.	Yield p c.
Brighton and Hove Ordinary	5	4½	5	5·55
Brush Electric Ordinary	3	3⅛	6	5·76
Do. Pref.	2	2⅛	6	5·64
Crompton and Co. Pref.	5	5½	7	6·57
Electric Construction	10	6	6	10
Hastings and St. Leonards Ord.	10	9½	7½	7·89
House-to-House Pref.	5	5⅜	7	6·51
Kensington and Knightsbridge Pref.	5	5¾	6	5·21
Liverpool Electric Supply Ord.	3½ (5)	3 7/16	4½	4·58
Do. Pref.	5	5⅛	4½	4·38
St. James's and Pall Mall Ord.	5	8⅜	8½	5·07
Do. Pref.	5	7⅞	7	4·44
Sheffield Tel. and Elec. Ord.	8 (10)	10⅜	7½	5·78
Swan United	3½ (5)	4	11	9·62
Telegraphic Construction, etc.	12	43	20	5·58
DEBENTURES.				
Brighton and Hove	100	95	6	6·31
Eastbourne	100	97½	6	6·15
House-to-House	100	102½	6	5·85
Telegraphic Construction, etc.	100	103	5	4·85

PROVISIONAL PATENTS, 1892.

APRIL 26.

7803. **Improvements in or appertaining to high-tension constant-current dynamo-electric machines.** Thomas Reginald Andrews and Thomas Preece, 20, Charles-street, Bradford.

7826. **Improvements in electric lamp shades as a medium for advertising.** Thomas Froggatt, 4, Moorfields, Fore-street, London.

7833. **An electrical metronome or time beater or regulator for musical and other purposes.** James Walker and Joseph Hampshire, 19, Bond-street, Dewsbury. (Complete specification.)

7855. **Electric switches.** Charles Ebenezer Challis, 88, Queen Victoria-street, London.

7858. **Improvements in the construction and insulation of electrical contact devices and like apparatus.** Max Binswanger, 11, Furnival-street, Holborn, London.

APRIL 27.

7915. **Improvements in electric switches.** Adolph William Isenthal, 46, Lincoln's-inn-fields, London.

7935. **Improvements in telephones.** David Marr, 70, Market-street, Manchester.

7961. **An improved electric circuit-closer.** George Washington Price, 55, Chancery-lane, London.

APRIL 28.

8041. **Improved telegraph codes and apparatus therefor.** Samuel Dickinson Williams, Clytha Park, Newport, Monmouthshire.

8046. **Improvements in electrical measuring instruments of the Cardew type.** Henry Capel Lofft Holden, Bernard Mervyn Drake, and John Marshall Gorham, The Cottage, Erith.

8062. **An improved machine for giving electric shocks automatically by the insertion of a coin.** George Bryant, 9, Warwick-court, Gray's-inn, London.

8064. **An improvement connected with thread-coating of electric wires.** William A'Court Granville Birkin, 166, Fleet-street, London.

APRIL 29.

8083. **A means of electrically heating iron, steel, and other metals in the processes of rolling, drawing, pressing, and stamping.** James Osmonde Dale, 12, Bennett's-hill, Birmingham.

8090. **Improvements in the production and regulation of electric currents for lighting and other purposes and in apparatus connected therewith.** John William Wignall, William Hirst, and John Smith, 4, St. Ann's-square, Manchester.

8108. **Improvements in the manufacture of metallic articles by electro-deposition.** Joseph Walker Davis and Joseph Osmund Evans, 55, Chancery-lane, London.

8115. **Improvements in and relating to posts or standards for carrying electric lights, wires, and the like.** John Bell Millar, 96, Buchanan-street, Glasgow.

8119. **Automatic make and break switch.** William James Ward, jun., 26, Osborne-road, Newcastle-on-Tyne.

8127. **Improvements in electric telegraphs.** Sydney Evershed, Woodfield Works, Harrow-road, London.

APRIL 30.

8165. **Improvements in electric meters.** Frederik Vilhelm Andersen, 14, Westdown-road, Catford, Kent.

8211. **Improved means for stopping or controlling electrical railway and tramway engines or carriages.** Michael Holroyd Smith and Thomas Percival Wilson, 55, Chancery-lane, London.

8212. **Improved means of holding and supporting electric conductors or otherwise, ropes or bars.** Michael Holroyd Smith and Thomas Percival Wilson, 55, Chancery-lane, London.

8213. **Improvements in coupling electric conductors and like wires.** Michael Holroyd Smith and Thomas Percival Wilson, 55, Chancery-lane, London.

8222. **Improvements in dynamo-electric machines and motors.** Wenceslas Camille Rechniewski, 98, Rue d'Assas, Paris, France. (Date applied for under Patents Act, 1883, Section 103, 31st October, 1891, being date of application in France.)

SPECIFICATIONS PUBLISHED.

1881.

4128. **Transmission of electrical power.** Imray. (Second edition.)

1891.

5711. **Electrical seamless tubes, etc.** Thame.
8811. **Recording electric meters.** Mengarini.
9606. **Telephone receivers.** Thompson. (Stein.)
9628. **Voltaic batteries.** Fitzgerald.
9629. **Voltaic batteries.** Fitzgerald.
9637. **Electric cut-out.** Alabaster and Gatehouse.
9689. **Electric batteries.** Jeanty.
9803. **Galvanic batteries.** Engledue.
10090. **Electrolytic production of aluminium.** Grabau.
10613. **Rotary-phase currents.** Siemens Bros. and Co., Limited (Siemens and Halske.)
14752. **Incandescence lamps.** Heald.
16451. **Electric train signalling.** Thompson. (Espiau and another.)
20530. **Ship telegraphs.** Cords.

1892.

2544. **Electrical motors.** Boult. (Still.)
3576*. **Distributing, etc., electricity.** Atkinson. (Second edition.)
3970. **Dynamo-electric machines.** Mills. (Lundell.)
4416. **Electric switches.** W. H. and G. W. Weston.
4610. **Electric gas lighting burners.** Pinkham.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2⅜
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5⅝
Metropolitan Electric Supply	—	8⅝
London Electric Supply	5	1
Swan United	3½	4¼
St. James'	—	8⅝
National Telephone	5	4½
Electric Construction	10	6¼
Westminster Electric	—	6[illegible]
Liverpool Electric Supply	5	[illegible]
	3	3⅜

NOTES.

Reichenberg, in Bohemia, is to have a central station.

Leeds.—The tenders for Leeds central station are to be sent in by the 26th inst.

Caspian Sea Cable.—It is intended to lay a submarine cable in the Caspian Sea.

Vienna Omnibuses.—The Vienna Omnibus Company are testing electric lamps for their vehicles.

Worcester.—The tenders for the Worcester central station have not yet been definitely decided.

Chili Telegraphs.—The new telegraph line from Argentine to Chili will shortly be completed.

Spain.—On May 15th the tenders will be awarded for the lighting of Tolosa, province of Guipuzcoa, Spain.

Lighthouses. — Her Majesty's Government have decided to spend £40,000 upon lighthouses in the Red Sea.

Derby.—The working expenses of the proposed Derby electric light town installation amount to nearly £3,000 a year.

Bournemouth.—The surveyor has been requested to order electroliers for the Bournemouth Municipal Buildings.

Ashton-under-Lyne.—The Board of Trade have decided to grant a provisional electric lighting order to this town.

Cardiff.—A special committee has now the consideration in hand of a new town hall for Cardiff. Electric light will doubtless be fitted.

Grangetown.—The surveyor at Grangetown is compiling a statement of comparative cost of gas and electric light for the Local Board.

Leeds Tramways.—A joint referee will be appointed at once with reference to the purchase of the Leeds tramways by the Corporation.

Madrid.—A project for utilising 3,600 h.p. of the River Guadawana to Torrelodones and Madrid is under consideration by the Spanish Government.

Personal.—Mr. W. E. Toy having qualified himself in the works of Mr. Ronald A. Scott, M.I.C.E., Acton-hill, W., his services have been retained as assistant engineer.

Perth Tramways.—The system of electric traction to be used by the Perth Tramway Company is not yet settled. It is thought accumulator traction is favoured.

Dinner.—A complimentary dinner is to be given to-night to Prof. W. E. Ayrton, F.R.S., by some of his former pupils and associates, at the Holborn Restaurant.

Bremen.—Messrs. Siemens and Halske's tender has been accepted for Bremen for a complete central station, mains, and house connections during first year for £95,000.

Technical Schools.—The surveyor of Hartlepool has been instructed to prepare plans for a technical school. The Stockton Town Council are going to spend £6,000 on a technical school.

London Hotel Lighting.—The well-known hotel in Charing Cross and Trafalgar-square known to the world as Morley's, is being fitted for electric light by Messrs. Mather and Platt.

Brussels.—It is understood that the electric lighting of Brussels is to be proceeded with shortly. It is stated that the favourably reported scheme is that of the India Rubber and Gutta Percha Company.

West of England.—A company has been registered as the Western Counties Electric Light and Power Company, to carry on the business of Messrs. Parfitt, the firm who are lighting Kingswood and Keynsham.

Newcastle Trams.—The Town Improvement Bill for the Newcastle Corporation provides for a double set of tramrails along Westgate-hill. It is not settled whether steam, cable, or electric traction will be used.

Tunbridge Wells.—The Tunbridge Wells Local Board is waiting applications for transfer of its electric lighting powers to a private or other company. The cost of the provisional order for the electric lighting of this town was £350.

Blackpool Tramways.—The Court of Referees of the House of Commons has decided to give the National Telephone Company a *locus standi* with reference to the Blackpool Tramways Bill upon two clauses for the purpose of asking for protective clauses.

Nelson.—The Local Government Board have asked for plans and other details relating to the electric lighting of Nelson, with respect to which an application has been made to borrow £10,000. These plans have been prepared and forwarded to the Local Government Board.

St. Ives—The cost of public lighting in St. Ives for last year was £124, gas being at 5s. 6d. per 1,000. St. Ives should form a good district for a small electric light central installation, for it is not often that electricity has the chance of competing with gas at this high figure.

Monte Video Telephones.—Application has been made, says the *Financial News*, to the Monte Video municipal board for authority to establish a new telephone company, with subterranean wires. The Direction of Public Works has been asked to report on the scheme.

Inductor Dynamos.—A small company will be formed to manufacture the Pyke and Harris inductor dynamos. Continuous-current machines will be made, as well as alternate-current machines, on the same principle, and special transformer plant will complete the system.

Lambeth.—A letter was read at the meeting of the Lambeth Vestry, on the 5th inst., from the Board of Trade, stating that they were now prepared to issue a provisional order authorising the Vestry to supply electricity in the parish. The matter was left in the hands of the clerk.

Glasgow.—At the Glasgow Town Council meeting last week Councillor Ure, in submitting the Gas and Electric Lighting Committee's minutes, said that, in addition to certain gas contracts, the committee had passed contracts amounting to £11,240 in connection with the electric lighting of the city.

Bognor.—The Board of Trade have written to the Bognor Local Board to grant an extension of time until August 14th, within which the Electric Lighting Trust, Limited, should make the deposit required under the Bognor electric lighting order. They would not grant time beyond that date.

Dover.—The preliminary arrangements for the lighting of this town do not make much progress, there appearing to be some hitch with regard to the agreement. A considerable number of alterations have been made in the document, and a special meeting of the Council has been called to consider them.

Caravan de Luxe.—It is said that the Duke of Newcastle intends to make a gipsy tour, and for this purpose is having a *caravan de luxe* built, which is to be fitted with the electric light and all the comforts of civilisation necessary to supply the wants of himself and a photographic friend, with whom he proposes to travel.

Royal Institution.—On Friday, May 20th, at 9 p.m., Mr. J. W Swan is to read a paper before the Royal Institution on "Electro-metallurgy." As we believe Mr. Swan has been engaged for some considerable time on questions of the deposition of copper, this paper will doubtless have considerable interest and importance to electrical engineers.

St. Moritz.—The Alpine watering-places of St. Moritzdorf and St. Moritzbad have between them an electric lighting plant in three stations of five direct-current machines giving 160,000 watts, and alternating machines of 320,000 watts—taking a total of 1,000 h.p. The work has been carried out by Stirnemann and Weissenbach, of Zurich.

Sevenoaks.—At the last meeting of this Board a letter was read from the Board of Trade enclosing a communication from the promoters of the proposed scheme for supplying Sevenoaks with the electric light, and offering to revoke the order if the Local Board wished. A motion was duly carried to ask the Board of Trade to revoke the order as they offered to do.

Shiplighting. — Messrs. Lowdon Bros., electrical engineers, Dundee, have obtained an order from Messrs. William Thomson and Sons for the electric lighting of their new steamer "Iona," now being built by Messrs. Gourlay Bros. and Co. Messrs. Lowdon have just completed the installation on board the new D. P. and L. Co.'s steamer "London."

The Compass Needle.—Dr. A. H. Fison is doing very good work in giving popular and interesting lectures upon electrical subjects. A recent lecture at the Royal Victoria Hall, on "The Compass Needle," with large and vivid limelight illustrations, was much appreciated, and other lectures delivered by Dr. Fison have been very favourably received by those attending.

Electric Locomotives.—Contracts are stated to have been concluded for working trains through the Baltimore Belt Line Tunnel by 80-ton electric motors. The contractors are so confident of success that they have undertaken to instal the plant without any payment, unless they are entirely successful. Railway experts regard it as an ample and thorough test of the rivalry between steam and electricity.

Croydon Municipal Buildings.—Many of our readers no doubt know that Croydon is about to erect new municipal buildings, and in preparing the specification for the superstructure of the new buildings it is proposed to provide that the sum of £700 be set apart for wiring the building for electric lighting. With the exception of the pipes necessary for the gas engine, it is not proposed to lay in any gas-pipes.

Bradford Tramways.—At the Bradford Town Council on Wednesday, when the minutes of the Tramways Committee came forward, Mr. Joseph Cowgill, chairman of the committee, said that the question of discussing the use of electric traction on the Wakefield-road tramway was somewhat premature. At present the committee were awaiting the result of the experiment of running the electric car up Cheapside.

Ipswich.—The electrical industry has often to thank the various local scientific societies for bringing electrical apparatus prominently before the public. At the Ipswich Scientific Society's *conversazione* the other evening various pieces of electrical apparatus were shown by Messrs. F. Suter and Co., including an electric motor for supplying power for glass spinning. The generator was a small home-made dynamo, shown by Mr. Sayers.

Taunton.—As we before pointed out, the question of the town purchasing the electric light installation is a very interesting one, as it is the first of its kind. Hence it is as well to give the expert's report verbatim, which we do elsewhere in this issue. The sale and purchase of an installation as a going concern is an ordinary business transaction, and one in which undoubtedly both sides are quite capable of looking after their own interests.

Portsmouth.—The trials we alluded to last week at Portsmouth were not definitely to settle the use of incandescent lamps instead of arc lamps, as might appear, but merely to illustrate for the satisfaction of the councillors the lighting effect of the two systems. It is probable that a combination of arc and incandescent will be used. The whole scheme is now waiting the result of the Local Government enquiry, which is shortly expected, and meanwhile full plans are being prepared.

Birkbeck Lectures.—Mr. J. D. Crogan, the veteran lecturer on scientific application, gave a very interesting address at the Birkbeck Institution last week, entitled "From Tinder-Box to Electric Light." The lecturer passed through all the stages within his own recollection of 60 years, from the time he sold matches over the counter at 50 a shilling, or in some cases a penny a-piece, through the improvements in gas distribution, to the latest triumphs of electric light. The lecture was greatly appreciated.

Chiswick.—This is one of the places which desires to hand over the provisional order to other persons. Tenders were therefore invited and obtained from Messrs. Bourne and Grant, and Messrs. Andrews and Co., for the taking over of the provisional order for the lighting of the parish by electricity. The matter has been referred to a committee to consider the question. This committee consists of Messrs. Sich, Adamson, Fuller, Tappenden, H. Smith, Hardy, and the chairman, Mr. W. I. Compton.

Oxford.—The Oxford Electric Light Company, through their general manager, Mr. George Offer, proposed to the City Council the erection of five lamps, seemingly as experimental lamps, at the expense of the company. The current for the supply of these lamps, which will be Brockie-Pell of 2,000 c.p. nominal, is to be charged either at 6d. per supply unit by meter, or 5d. per hour for each lamp lighted. The General Purposes Committee recommended that this be agreed to, and the Council approved the recommendation.

Northampton.—A wrong impression might perhaps be given by the mere statement that the electric light was to give place to gas with regard to the lamps in front of the Town Hall at Northampton. The gas company have great claims to light these lamps, seeing that 27 years ago they presented the four lamp columns to the town, and have ever since lighted two lamps free, and the gas company will light the four lamps all night at £16. 15s., as against the electric light company's offer to supply two lamps of 200 c.p. each for £50.

Southend Pier Electric Tramway. — Messrs. Crompton and Co., electrical engineers, forwarded an exhaustive report, which was presented at the last meeting of the Southend Local Board, as to their inspection of the pier electric railway and the works in connection therewith. The report stated that everything was in fairly good condition, but stress was laid on the matter of corrosion taking place in the winter time, though by taking precautions in time no inconvenience would arise from that cause for some time to come. The report was referred to the Pier Committee.

Keynsham.—The contract of the Keynsham Local Board with the gas company having expired at the end

of February, the Board determined to have the electric light, and placed the matter in the hands of Messrs. Parfitt, who already had lighted Kingswood, near Bristol. A 10-h.p. Robey and a 12-h.p. Davey-Paxman engine are installed, and the light is to be supplied on a low-pressure direct-current system at 130 volts. The wires extend for about a mile, the roads being lighted for the most part by 25-c.p. incandescents carried on posts. A few smaller lamps are used in lanes, and some 125-c.p. incandescents in the centre of the town.

Closed-Conduit Systems.—A company with a million dollars has been formed in Illinois, to work the closed-conduit tram system of Mr. J. B. Odell. Mr. Mark W. Dewey is working on another closed-conduit system, which is to work by induction with alternating currents. Mr. Elias E. Ries is also at work on a similar system. Mr. Ries is in advance of Mr. Dewey, as he has already made practical demonstrations. It is thought, no one can yet judge with what truth, that these methods may entirely revolutionise present methods of car traction. Between closed conduits and the light-weight heavy-discharge accumulator, the race, however, will be close.

The House of Commons Signal Light.—It costs £60 every session to keep up the signal light on the Clock Tower at Westminster. The light is at present so placed that it can only be seen from certain positions, and the First Commissioner of Works has promised to make provision in next year's estimates for altering the position in such a way to make the light visible from all quarters with the assistance of lenses. Mr. Plunket does not, however, see his way to use electricity instead of gas for this illuminant. The initial cost of an electric light in the upper part of the Clock Tower, which would be visible from all parts of London, would be about £750, and the cost each session about £150.

Electric Launches.—Mr. W. S. Sargeant, whose business is now converted into the Thames Electric and Steam Launch Company, is busy fitting out their electric launches for the coming season. The "Glowworm" is one of the best known of these, designed for Andrew Pears, Esq., and the "Pilot," an electric pinnace, is another boat built by Mr. Sargeant for the same gentleman. Other electric boats at Eel Pie Island and Strand-on-the-Green are the "Meteor," built for Arthur Ash, Esq., and the "Florentia," for W. T. Crawshay, Esq., of Caversham Park, Reading. The growing popularity of electric launches for private owners up the Thames is a good augury for the future extension of this branch of electrical engineering.

Glasgow Electric Lighting.—The following are the tenders accepted for this work: (1) Offer dated 25th ult., by the Henley Telegraph Works Company, Limited, for the half square inch insulated cables and triple potential leads, and offer dated 22nd ult., by the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, for the quarter square inch insulated cables; (2) offer dated 25th ult., by Elliot's Metal Company, Limited, for the copper strip; and (3) offer dated 25th ult., by Mr. Wm. Pollok for excavating the trenches and laying the electrical conductors; (4) offer dated 5th ult., by Messrs. James Stiff and Sons for the insulators; and (5) offer dated 13th ult., by the Crompton-Howell Electric Storage Company, Limited, for the storage cells.

East Molesey.—We are pleased to see that there is a disposition apparent to favour the introduction of electric light in the smaller towns. Weybridge is already supplied, and now East Molesey is trying to follow suit. At the last Local Board meeting, the General Purposes Committee reported that Mr. Everett had laid before them plans and specifications for lighting the village by electricity. The committee stated they were disposed to view such scheme favourably, provided the interests of the parish were safeguarded by provisions as to the time in which the work shall be carried out, as to the price for the supply, as to the power of purchasing the concern, and such like matters. The committee promised to report further on this matter at the next meeting.

London Telephones.—The New Telephone Company is evidently intending to make immediate progress. We see by an advertisement in the daily press that the supporters of the company's telephone exchange system in London already number over 1,800. The Association for the Protection of Telephone Subscribers (58, Coleman street), after stringent investigation, has decided to give its undivided support to the New Company. The public are invited to test the company's instruments at 110, Cannon-street. Intending supporters may obtain the service at a lower rate if applied for at once, as the first 5,000 who apply will only be charged 12 guineas a year. The movement will give great satisfaction, we fancy, to the numerous business houses in the City.

Blackpool.—The report of the gas manager upon the present electric lighting on the Promenade is expected shortly. It would have been ready before but for the fact that the Council has increased the number of hours far above that originally estimated during which the light should be used. Had they allowed the control to remain with the gas company, we are informed that the electric light would have been extended along the greater portion of the Promenade. It is certainly refreshing to learn—as we are given to understand from various quarters—that gas committees in many instances are not so bound up in gas that they refuse to see the advantages of electric light, and in not a few places the initiative has been taken—for example, at Bradford—by the Gas Committee to introduce the competing illuminant.

Telephony.—The article we gave in our last issue has, as we expected, been taken as a manifesto of the National Company, and, of course, we think it an exceedingly able manifesto. We are now able to give the reply to this manifesto. Our readers can compare the arguments on both sides and make their own conclusions as to which makes out the better case. Our own opinions have been often and freely expressed, and may be condensed into the following statements. The London service of the National is condemnably bad and dear. The Government own the telegraph system, and telephony being a phase of telegraphy, unless the Government owns the telephonic system it is in danger of losing its capital and its business. We think the Government ought to do the work. It seems settled, however, that there is no possibility of this, and the next best scheme is to support a company that will do its work properly.

Bideford.—It may have been noticed that a correspondent wrote requesting information as to the electric lighting at Bideford in our last issue. According to the report of the adjourned meeting of the Town Council—who are slightly at loggerheads with the gas company—it was proposed that the estimate from Tardrew and Son for the supply of electric light be opened. This was done, and the estimate showed that the plant for the electric light would cost about £4,680, and the annual cost of maintenance about £620. To some of the members the cost of maintenance appeared rather high, but it was suggested that if the Council erected an electric lighting plant of their own, they could supply private consumers and make a profit. Last year they paid £490 to the gas company for the town lamps. It was agreed to pay Messrs. Tardrew and Sons

twelve guineas for preparing the electric lighting estimate, and the question was referred to the committee.

Sale Catalogue.—We have received from Messrs. Wheatley Kirk, Price, and Goulty a catalogue of electrical apparatus which is to be sold by auction on Tuesday and Wednesday, May 17 and 18. Among other things, the catalogue includes Brush and Willans engines, Babcock-Wilcox boilers, dynamos, transformers, carbons, arc lamps, and a very large number of switches, roses, fuses, shades, globes, etc., as well as instruments and other paraphernalia of a general electric business, which is comprised in the estate of Messrs. Nicholson, Jennings, and others. We note also that there are several patent rights to be sold on the second day of the sale—viz., patents No. 17,479, of November 13, 1888; No. 4,703, March, 1889; No. 9,917, June 17, 1889. The whole of the rights in the above patents to be sold, and a half share of No. 19,695, December 7, 1889.

Electricity on Board Ship.—The paper which we reproduced last week on electricity applied to naval purposes, by Lieutenant F. T. Hamilton, has attracted a good deal of attention in public circles; more particularly perhaps, because the Duke of Edinburgh was present at the meeting of the Royal United Service Institution on the occasion. After the lecture, the Duke complimented the author, and said that he could help feeling at the same time that it would not be well to run too much risk in trusting to electricity, or lay ships open to disaster if a single wire were cut or out of order. He described some electric fan ventilators in use on board the yacht of the Czar of Russia, and said that while they were very effective they unfortunately made a considerable noise, and it was a temptation to obviate the noise at the sacrifice of the fresh air by stopping them. Some of our readers may be able to recommend less noisy electric fans for ship use.

Ludlow.—At the monthly meeting of the Town Council an application was made from the British Electric Installation Contractors, of Worcester, for the sanction of the Council to their making application to the Board of Trade for a license to supply electricity to the town. The Worcester Company intended to transfer the license, if obtained, to the Ludlow Electric Lighting Company, when that company had been registered. This application has been referred to a committee, consisting of the Mayor, Alderman Valentine, and Councillors Lloyd, Chubb, Marston, Weyman, Tyrrell, and Smith. It seems to us that this committee should carefully consider whether it is in the interests of any local authority to permit a mere act of company-mongering, which this seems to be, where one company obtains a provisional order and then transfers it to another company—of course with a view to profiting directly by the transfer and also by obtaining the work of the installation.

York.—The Sub-Committee of the York City Council had a conference with Mr. Crompton, who is acting as their consulting engineer, on Monday, and subsequently presented a report to a meeting of the Streets and Buildings Committee. The meeting was attended by representatives of the three firms which had submitted estimates—viz., R. E. Crompton and Co., Limited, the Parsons Company (Newcastle), and the Brush Electrical Company. The first-named company, which was represented by Mr. Crompton, submitted estimates based on the low-tension principle; whilst the others estimated the cost of an installation on the high-tension system. Eventually the committee requested Mr. Crompton to prepare a specification for the public and private lighting of a given area, and the Council will be asked to sanction an application for tenders in accordance therewith. A canvass of the town is in progress, and the replies already received promise consumers to the extent of 3,000 lights.

Vibratory Currents.—Mr. Frank C. Perkins has rather "struck oil" in the way of copy for the *Electrical World*, by asking electrical celebrities on this side to give their opinion as regards Tesla's experiments, whether the effects are due to high potential and high frequency alone, and whether Ohm's law can be said to hold good. Mr. Preece, Prof. Hughes, Mr. Kapp, Prof. Hopkinson, Prof. Ayrton, Mr. Crookes, Prof. S. P. Thompson, Prof. Fleming, Mr. A. Siemens, Mr. Swinburne, Mr. Wimshurst, Mr. Crompton, various editors, and Sir W. Thomson have replied. The result of it all is, of course, "we don't quite know, but we think so," or "think not," as the case may be. And here it must evidently remain until we gain more actual experience in vibratory currents. Ohm's law, however, comes out as the Yankees say, "battered, but still in the ring." Some disbelieve in Ohm's law for alternating currents, and talk of ohmic resistance. Mr. Swinburne considers "Ohm's law holds good for all frequencies, though self-induction becomes more important in high frequencies." Prof. S. P. Thompson says Ohm's law is not a question of opinion, "but a question of fact." Lord Kelvin (Sir William Thomson) regretted he did not see Tesla's experiments.

High-Speed Electric Railways.—The question of high-speed railway trains driven electrically is receiving attention at the hands of electrical engineers in both America and France. In America, Mr. O. T. Crosby and Mr. David Weems are credited with practical projects for the production of what are now regarded as abnormal speeds. In France, M. Heilmann has given some attention to the problem, his idea being to generate electricity by means of a special engine and boiler on board the locomotive, using the electrical energy to rotate the car wheels. We notice that two prominent engineers—M. Bonneau, assistant chief engineer to the great Paris-Lyons-Mediterranée Railway, and M. Desroziers, electrical engineer, whose name is well known in dynamo construction—are now bending their attention to the use of electricity for high-speed railway trains. It is thought possible, by means of electric traction, that the run from Paris to Marseilles, 862 kilometres, now accomplished in 15 hours, might be done in nine hours. The arrangement proposed by MM. Bonneau and Desroziers consists in employing motors on two independent axles, the diameter of the wheel being 2·30 metres (7½ft.), with rail conductors. Some particulars and drawings are given in the *Revue Industrielle* of the electric locomotive, but it does not appear that the project has yet got into the practical stage.

Electric Lighting in Scotland.—Benmore House, the residence of Henry J. Younger, Esq., is to be lighted by electricity, and we are informed that the contract for the carrying out of the work has been placed with Messrs. Ernest Scott and Mountain, Limited, electrical and general engineers, Close Works, Newcastle-on-Tyne. The installation will consist of a Priestman oil engine capable of working up to 18 brake h.p., driving a Tyne shunt-wound dynamo of 12,000 watts capacity; accumulators will be supplied for storage, and will be placed in the accumulator-house, next to the dynamo-room, the battery or accumulators being capable of maintaining 80 arc lamps for 10 hours when fully charged. The total number of lamps installed throughout the house will be about 180 to 200. Mr. W. A. Bryson, of Glasgow, has been appointed superintending engineer on behalf of Mr. Younger, and Messrs. Mountain and Co., of 7, Bothwell-street, Glasgow, representatives for Messrs. Ernest Scott and Mountain, Limited, in Scotland, will superintend the carrying out of the work. Through their

Scotch agents, we are informed that this firm have already supplied numerous electric light plants, including installations for the firms of Messrs. Paterson, Elder, and Co., Messrs. Cran and Co., both of Leith, Messrs. Hutchinson and Co., of Kirkcaldy. They have also recently completed contracts for the lighting of the Glasgow Iron and Steel Company's works at Wishaw, and one of their collieries at Motherwell.

Oakamoor.—Some of our readers may know that the Staffordshire County Council entered heartily into the scheme of having popular lectures on technical subjects in various parts of the county. The last of the series of lectures on "Electricity and Magnetism" under the technical instruction scheme of the County Council has been given in the schoolroom by Mr. D. O. S. Davies, B.Sc., under the presidency of Mr. A. S. Bolton. The series, which has been well attended throughout, has been very successful, the greater interest being shown perhaps in those lectures dealing with electric lighting by dynamo and battery, the electric telegraph, and the telephone. For the purpose of popularising the subject, Mr. Davies has been very happy in his general references to the uses, domestic and otherwise, to which the concentration of the lines of force can now be put. Among these are the heating of curling-tongs and flatirons, the cooking of chops and steaks, and the boiling of saucepans and kettles. These comparatively minor details, together with the copious experiments, have made the series both entertaining and instructive. At the conclusion, Mr. Bolton, in proposing a vote of thanks, spoke warmly of the services rendered by the lecturer to the spread of the science in the district. A vote of thanks to the president brought the series to a close. It is suggested to have an extended course early in the autumn. Perhaps, as an outcome of these lectures, and the interest taken therein, may be attributed the fact that in the private theatricals given in the new schools electricity was called in to light the stage.

Londonderry. — The recently-appointed consulting engineer to the Londonderry Corporation, Mr. Henry W. Blake, is a resident of Manchester, and has for some years been carrying out consulting work in steam and electrical engineering. He was educated at Victoria College, and passed through all stages of mechanical engineering in the shops, afterwards establishing his own laboratory in Manchester. He has carried out several important electrical installations both in the North and South of England—in London, a large mill at Bermondsey, 700 incandescents; in Portsmouth he was retained by the Admiralty to engineer the lighting at the festivities on the visit of the French Navy last year, and was engineer to the Portsmouth Town Hall, about 1,000 lights, with Mather and Platt dynamo—one of the largest, if not the largest gas-engine-installations in England. The then Mayor (Sir William King) bore witness to the excellence of the lighting, and this led to his being called in as one of the consulting engineers to submit plans for the town lighting of Portsmouth. He advocated high-tension continuous currents, but the low-tension system was then chosen, afterwards, however, as is known, changed to high-tension transformers. Mr. Blake had previously carried out a large mill installation in Londonderry of over 1,000 lights, which no doubt led to his being selected from the 32 candidates for the town lighting. Derry is a scattered town, though walled, and the high-tension system should be used, but on account of the power that could be taken up, a system allowing the use of motors would be preferable.

Messrs. Siemens's Works.—A description which may be justly mentioned as one of the feats of trade journalism is given of the works of Messrs. Siemens Bros. and Co., Limited, in the *Manufacturers' Engineering and Export Journal* for April. The bulk of the paper, 50 pages, is taken up with a most elaborate descriptive article, with many full-page illustrations, and it certainly gives to those who do not know the place a very accurate idea of the immense activity of the Siemens electrical works on the banks of the Thames at Woolwich. Portraits are first given of the late Sir William Siemens and of Mr. Carl Siemens and Dr. Werner von Siemens, with an historical sketch of the progress of the individuals and the firm, from the landing of William Siemens in England in 1843, with a sand-bath thermopile for electroplating, to the erection of the present works. A copy of Dr. Werner's letter, quoted from Dr. Pole's book, announcing his original discovery of the self-excited dynamo, makes interesting reading. A list of the cables laid by the firm is also given. Photographs of the long line of buildings and of the interiors of the shops are exceedingly interesting to electrical engineers. We are shown the automatic shaping shop, the braiding shop, the indiarubber-mills, the testing-rooms, and the cable-tanks. The main dynamo fitting shop shows a scene of exceeding activity, and the instrument shop is an avenue of lathes. The various departments of heavy machine construction are very well brought out in the photographic reproductions. We are afterwards shown views of the telegraph ship "Faraday," with deck views in process of hauling cable, and, finally, a number of manufactures, consisting of electrical instruments, dynamos, cables, and the other well-known specialities of the firm. Altogether, the article makes a very comprehensive review of the present state of electrical manufacture. The paper is published at 22, Paternoster-row ; price 1s.

Storage Battery Traction.—Mr. J. K. Pumpelly has been engaged upon the development of storage batteries for traction purposes for some time past in America, and has produced one or two variations on the well-known models of plates. He now gives some account in the *Western Electrician* of recent progress in that direction. The objections, he says, to the use of storage cars are well known : want of durability over any large length of time, cost of manufacture and cost of renewals. Within the last few months his attention has been drawn to excellent results attained by two young men in Des Moines, Iowa, one a practical worker in batteries and the other a prominent chemist, the president of the State Laboratory of Pharmacy of Iowa. After spending much time in improving the pasted or Faure battery, they turned their attention to developing the Planté or formed lead cell. In their cell the lead plates are made very rapidly by folding long strips or ribbons of lead about ½in. wide and ⅛in. thick. The plates are immersed in a certain salt solution as electrolyte, and a large current from a dynamo is turned on. In 10 hours the plates have become one smooth plate of spongy lead, black as slate, yet very absorbent of hydrogen. Nothing remains but to separate these plates, connect up, and charge as a battery for 10 hours more. This done, the plates are ready for use or shipment. Mr. Pumpelly has seen this battery tested under heaviest work, and the plates, instead of appearing to disintegrate, grow firmer. The battery holds its pressure of over two volts to the cell under very heavy discharge until 90 per cent. of the charge is drawn out—that is, there is not the usual drop in voltage. A car built to hold six men is guaranteed by the inventor, with 24 cells, to run at 13 miles an hour, and the battery can be recharged in three hours. A battery in use eight or nine months, says Mr. Pumpelly, showed no signs of crumbling, and a discharge by short-circuit of 500 amperes seemed to produce no harmful effect at all.

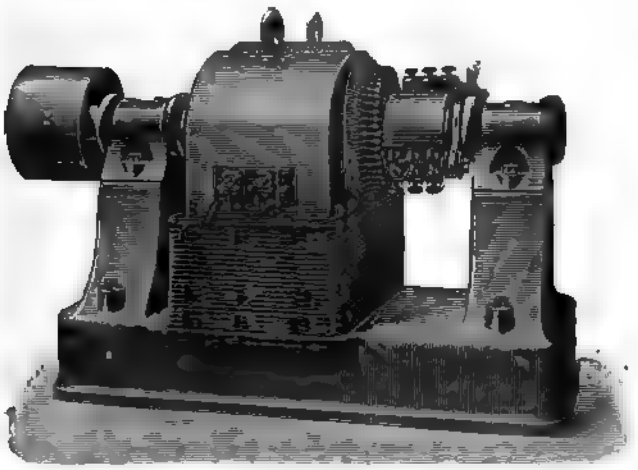
THE CRYSTAL PALACE EXHIBITION.

DIRECT-CURRENT DYNAMOS.—VII.

BY R. W. WEEKES, WHIT.SCH.

The accompanying illustration of the Roper Engineering Company's 10-kilowatt cast-iron dynamo arrived too late for insertion in our last issue. This shows the construction of the machine, and how the exciting coils can be slipped on over the poles.

Messrs. Easton and Anderson exhibit some machines which are worthy of careful inspection. The field magnets are of the Manchester type, so designed that the armature reaction shall distort the field as little as possible. As



Roper 10-kilowatt Dynamo.

described in a previous article, the armature is of the Pacinotti type, and the distance between the projecting teeth of the core and the poles is much less than the corresponding distance in a smooth-cored armature. The advantage of this is that the magnetising force required to saturate the iron core is small, and hence the exciting coils can be made short and compact. The short air gap, however, has the disadvantage of increasing the distortive effect of cross ampere-turns on the armature. If the cross ampere-turns were the same as in a smooth-cored armature of the same size, the distortion produced would be greater in the inverse ratio of the length of the air gaps. From

required. The path of the lines of force induced by these cross turns was shown in Fig. 27, and it will be seen from this that if the pole-piece is made thin in the centre, additional resistance will be placed in the path. So in these machines, the pole-pieces, which are made of cast iron, are reduced to a very small section at the centre, as can be seen in the illustration. The result is that the distortion is reduced to reasonable limits, and the machines run sparkless at all loads and without excessive lead at full load. The general details of these dynamos are excellent. The magnet cores are of wrought iron, and

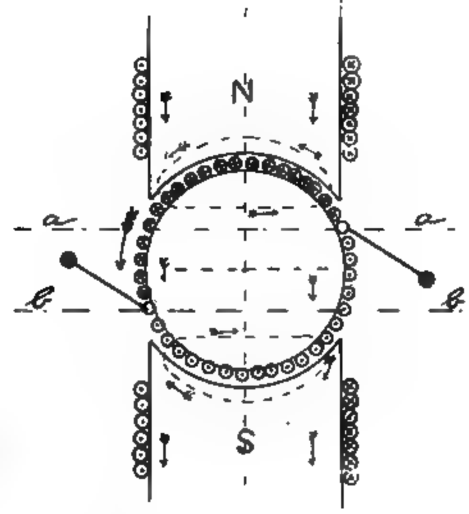
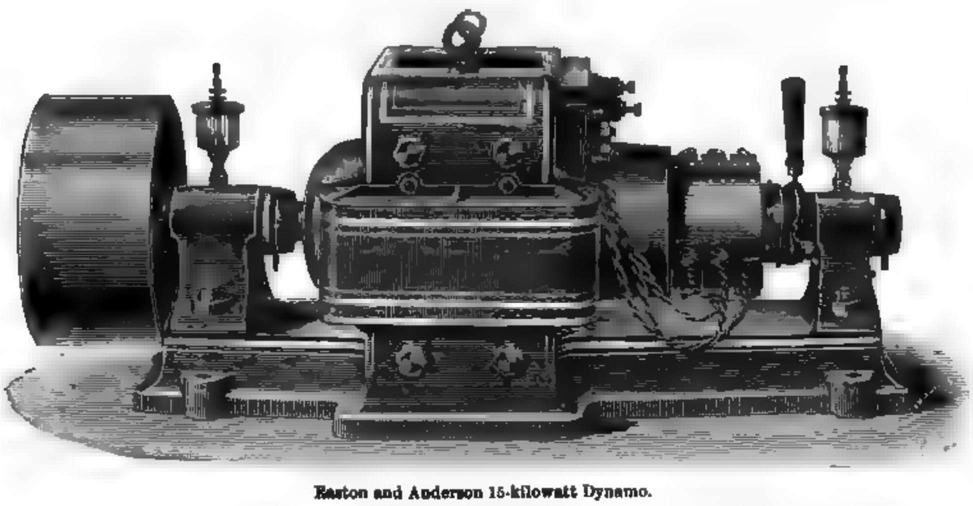


FIG. 27.

are bolted on to the cast-iron pole-pieces. These, except at the centre, are made with ample section to reduce the magnetic resistance. The exciting coils are wound on formers, and are carefully protected against injury by a metal casing. The bearings are of exceptional length, being at the driving end five times the diameter of the shaft. The 15-kilowatt belt-driven dynamo shown by this firm has the highest weight efficiency of the machines listed, and the larger direct-driven dynamo of the same output also stands high. In these larger machines the induction used in the armature core is not so high as in the small machines. This keeps down the hysteresis loss, and partly accounts



Easton and Anderson 15-kilowatt Dynamo.

this it will be seen that the distortion of the field tends to become excessive even in small machines, in which this type of armature is used. That this is so is shown by the care taken to reduce this effect by the special design of field magnets adopted by this firm and Messrs. Laurence, Scott, and Co., who use the same type of armature. Messrs. Easton and Anderson, in their smaller machines, work at a very high induction in the armature core, and hence get fewer turns of conductor, and correspondingly fewer cross ampere-turns on the armature at full load. This helps to some extent, and may reduce the cross turns as much as 15 per cent., but naturally increases the exciting power for the lower figure. This good feature, coupled with the mechanical driving of each conductor, should make these machines of special value for tramcar work, where light weight and ability to withstand the large forces required in starting are of primary importance. In fact, these makers are supplying some motors for the tramcars at Bradford for experimental purposes, but the type of field used is different to the above.

The four-pole dynamo exhibited by Messrs. Laurence, Scott, and Co. is coupled to an engine for use as a ship-lighting plant. The armature is of the Pacinotti type, and works with a small air gap between the polar surface

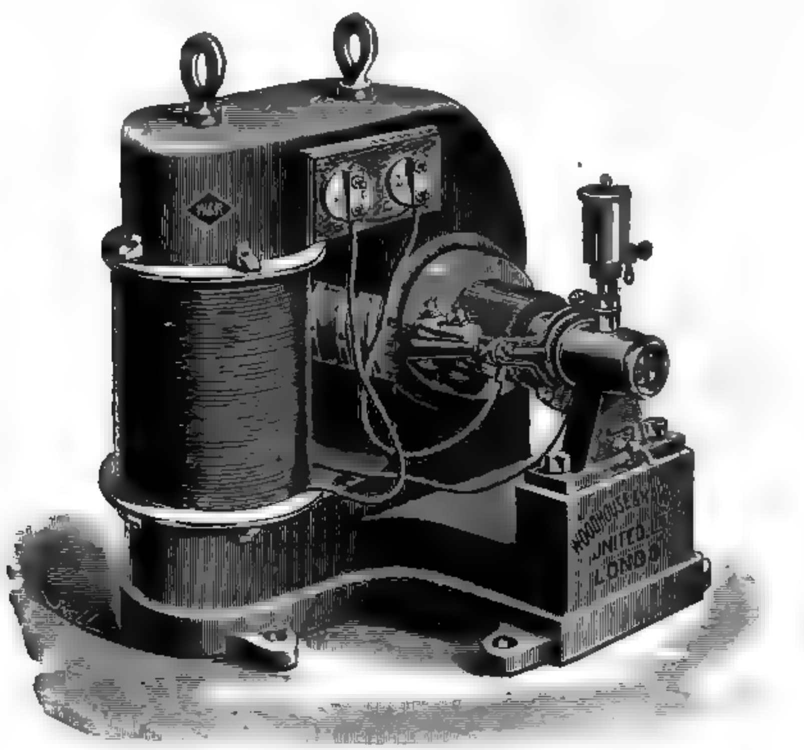
and the projecting teeth. The method used by this firm to prevent the distortion of the field is similar in principle to that described above, but it is carried to the extreme. Instead of reducing the iron to a thin section in the centre of the pole-piece, this firm construct their field with an air gap at this point. The construction is briefly as follows. Each magnetic circuit in the field consists of a distinct horseshoe of cast iron, embracing a little less than a quarter of the armature. These separate magnets are placed so that the distance between them is about $\frac{3}{8}$in. Thus any section taken through the polar surface would show these four distinct magnets, but the yoke is made broader than the poles, and continuous, so as to unite these separate circuits into one casting or two as the case may demand. In this way the variation of induction at any two parts of the polar surface is reduced to a quarter of what it would be if the pole were solid. This firm also claims that these gaps reduce the Foucault current in the wire. The reason of this would be that the excessively high induction at the exit edge of the polar surface is reduced, but care must be taken that the gap in the poles is not wide enough to allow of an appreciable fall of induction, or there will be additional loss due to the Foucault currents produced as the conductors pass the gaps. In the machine in question the gaps are $\frac{3}{8}$in., which is about four times the space between the pole and the armature core, and this is about the utmost limit allowable. The general construction of this dynamo is excellent. The exciting coils are wound on formers and slipped on from the inside. The armature is drum wound, and the ventilation of the cores is ample.

Messrs. Woodhouse and Rawson exhibit one of their Cornbrook dynamos, used as a motor to drive the Kingdon alternator. The machine is of the single-exciting coil type, which almost every firm has attempted to make at some time, but has generally been abandoned or confined to small motor work. There must necessarily be a much higher induction at the parts of the poles nearest the exciting coils, and this want of magnetic symmetry is the great failing in this type of field.

Messrs. Crompton and Co. use the double-circuit type of field magnet for nearly all their dynamos. In the small machines the magnets are arranged vertically, but in the larger machines the horizontal form is used. Their usual method of building the magnets is to make them of bars of wrought iron, of square section, and of such dimensions that the iron can be rolled instead of forged. Then a number of such bars are placed side by side to build up the magnets of the large dynamos. Thus in their 112-kilowatt dynamo the magnets consist of a set of six bars, placed side by side, each bar being 6in. square. Wrought-iron pole-horns are dovetailed on to the bars when required, to give the necessary arc of contact. The yokes are made of solid pieces of wrought iron, and the bars are bolted on to these before being bored out to the final diameter. The main advantage of this double-circuit type of field is that the induction is symmetrical provided the exciting power in each circuit is the same. If this is not the case, or there should be any great inequality in the iron used for the different circuits, the field may be quite as unsymmetrical as in the single-circuit types of magnet.

The constant-current dynamos exhibited by this firm can be used either for arc lighting in series or the series system of driving tramcars. The special feature of the machine is the method adopted for regulating the pressure to suit the load. This is done by rotating the brush carriers forward past the neutral axis till the right potential difference is obtained. Then in each of the armature circuits we have a certain number of conductors with E.M.F. in them opposed to the current actually flowing through them. Hence the effective E.M.F. is the difference between the two opposing forces. This seems simple, but the difficulty arises in getting the dynamos to submit to this treatment without sparking. This is done by so shaping the poles that the induction passing into the core is constant for a considerable area inside the approaching horn, and also is just the induction required to reverse the current in the segment short-circuited while passing under the brush. In this machine the above conditions are obtained by boring out the cast-iron pole-pieces to a larger diameter than required, and so placing them that the distance between the pole and armature core increases towards the horns. The automatic gear for moving the brush carriers consists of a solenoid energised by the main current, which actuates one of two pawls on a rocking lever, which, when in gear, rotates the brush carrier till the proper current is again obtained. One pawl is brought into action if the current falls and the other if it rises above the correct value. The machine is well made, and it is a pity it is not shown at work so that the automatic working can be watched.

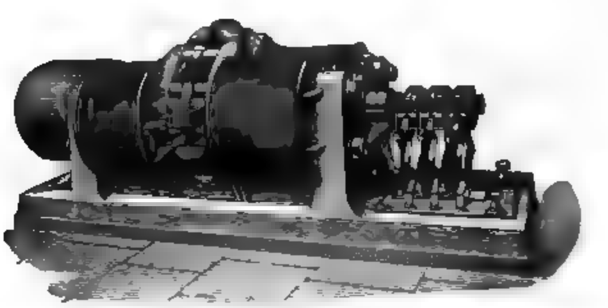
The larger four-pole dynamo made by this firm for central station work was illustrated in a previous article (*vide Electrical Engineer*, April 15, 1892). The general shape of the field is much like the double-circuit horizontal type. The method of building the field up of rolled bars has been



Cornbrook Dynamo.

abandoned in this case, and slabs of iron, 14in. by 12in. section, are used. The two yoke-pieces are also forgings. These pieces are 8in. thick, which is the distance round the armature surface between any two poles. As will be seen in the illustration of this machine, the lower magnet bars are supported by gunmetal brackets at both ends, and to secure perfect rigidity the poles are stayed together by gunmetal links at the front and back surfaces. This machine will not have a symmetrical field like the two-pole double-circuit type, but the want of symmetry will not cause any mechanical strain on the bearings. The field practically consists of two ordinary two-pole field magnets with shortened pole-pieces fitted to one armature. Hence, as in the two-pole machines, the induction will be higher at the places through which the shortest magnetic path passes, and in this case that is at the edges which lie nearest the horizontal line through the centre. The pull caused by one side will be balanced by that on the other, but the result electrically will be still detrimental, and most likely will reduce the non-sparking position of the brushes to a smaller area than if symmetry had been obtained. This machine is not working at present.

Messrs. Johnson and Phillips show the largest multipolar dynamo in the Exhibition, and also have on their stall the first experimental machine they manufactured of this type. The general principle underlying the design is that of a massive yoke ring with internal poles projecting from it. This ensures little stray field, and gives ample space for the exciting coils; also this form gives a perfectly symmetrical field, and ensures both mechanical and magnetic balance. Both machines are made



Brush Dynamo.

entirely of cast iron, but the recent dynamo supplied by this firm to the St. Pancras Vestry had wrought-iron magnet cores.

As the four-pole arc lighter is, as stated, an experimental machine, it will be well to consider chiefly the eight-pole dynamo shown coupled to the Paxman triple-expansion engine. In this machine the half-yoke ring and four of the magnet cores form one casting, and so there are very few joints in the magnetic circuits. The rectangular pole-pieces are also made of cast iron, and fastened on to the magnets by countersunk screws after the exciting coils have been slipped on. The magnets are of circular section, as this is the most economical form, and uses the minimum of copper in the exciting circuits, and also the coils are more easily wound than if a rectangular section were used. The number of cross ampere-turns on the armature per pole is not large because of the number of poles used, and at all loads the machine runs absolutely sparkless. Owing to the large diameter of the armature, the iron core occupies a comparatively small part of the diameter, and the central part is thus left open and ensures perfect ventilation. In fact, the heat can be dissipated so quickly that armatures of this type, when short-circuited by faults in the mains, have not burnt out, as is usually the case, but have taken the excessive current unharmed.

The weight and floor-space efficiency for this machine are both high, and if allowance is made for the fact that the frame is made entirely of cast iron, the weight efficiency would then be equal to that obtained in the four-pole machine of the same output made by Messrs. Crompton and Co. The high value obtained by both these dynamos justifies, if for no other reason, the use of the multipolar types.

The Gulcher Company exhibit one of their well-known types of dynamos for arc lighting on the parallel system. The field is of the four-pole double-circuit type, used by these makers and the Brush Company, with disc armatures. The difficulty in this type of dynamo is to keep the armature central in the field. If the core should for any reason be slightly nearer one set of poles than the other, a magnetic force tends to pull the core still further over. In this machine there is provision made for adjusting the two bearings at any time by screws till the armature is again central when any displacement occurs.

The other direct-current dynamos in the Exhibition which I have not mentioned are mostly exceedingly well-known machines, such as the Brush and the Thomson-Houston arc lighters, both of the open-circuit type of armature. The Thomson-Houston direct-current dynamo is of the four-pole internal type, but the details of construction could not be obtained.

In conclusion, I have to thank the representatives of the various firms exhibiting for the prompt and courteous manner in which they have answered all my many enquiries for the particulars of their machinery.

TELEPHONY—A REPLY.

The article which we published last week on telephony has directed keen attention to the probable tactics of the National Telephone Company in the impending crisis. Assuming the article to be an authorised statement of the position of the National Telephone Company from their own point of view, it was suggested to us that it would be but right to allow their competitors, the New Telephone Company, to have their say in the matter. That company has accordingly furnished the following information as showing their view of the question.

The National Telephone Company is, according to the recently-published and uncontradicted findings of independent investigators, so enormously overloaded with capital that it is unable to make progress even if it would. It would be bad taste on the part of an opponent to cite particulars on such a topic, but it is permissible to state so much, seeing that the National Company have allowed the recent article in *Truth*,* which professed to dissect their financial condition, to pass unchallenged.

In acting as they have been lately doing, the National Telephone Company have imitated one of Dickens's characters, who behaved at the funeral as if he alone were "notoriously immortal." They have seemed to forget that their patents would ever cease, and that without exclusive patent rights any ill-management must rise up in judgment against them. The fact has been lost sight of in the history of the telephone that at first there was no exclusive right given by the Government. Licenses were granted to several persons, and the sole reason why these have not been proceeded with has been the exclusive possession of the controlling telephone patents by the National Company. Mr. Fawcett had the idea that the telephone service of Great Britain should be put up to full competition. He granted licenses whenever asked, without much enquiry, and not only gave them to duly registered telephone companies, but to sundry private persons and firms. One of these licenses was granted to the Stanhope Company, one of the partners of which became possessed of a patent for a vibrating parchment diaphragm. Another license was granted, as is known, to a company — the original New Telephone Company—formed to carry out patents of Prof. S. P. Thompson, which was originally in the hands of Lord Thurlow, Lord Sudeley, Mr. John Sellon, Prof. Thompson, and Mr. Courtenay. It is this company that the present New Telephone Company is based upon. The old company was entirely bought up—assets and liabilities; liquidated and reconstituted. The last license was obtained by Mr. Provand, M.P. for one of the divisions of Glasgow, his idea being to

* See *Truth*, March 10, 1892.

start telephone exchanges on the co-operative principle throughout the country. The business of this company—the Mutual—has also been bought up by the New Company, thus securing then, as a basis for their system the twin-wire exchanges established by the Mutual in Manchester and Bolton with the trunk wires between them, as well as the services of Mr. A. R. Bennett, whose talents as a telephone engineer are widely recognised. This system—which has given great satisfaction, and has grown by leaps and bounds since its opening in February, 1891—the New Telephone Company purchased for exactly what it cost, with not a penny for added capital. There are, therefore, three going companies comprised in the New Company—viz., the Mutual, the New (S. P. Thompson), and the Stanhope.

From a public point of view, their present position, to which it appears from their manifesto the National Company take grievous exception, has been forced upon Government by simple business considerations. The Post Office hold the telegraph monopoly, and have paid a large sum of public money which it is absolutely necessary to safeguard. The Post Office have power to run wires without having to pay much for wayleaves; they have power to place wires underground, and have also running powers along railways. The telephone companies have permission to lay trunk wires, but no power either along railways or highways, and have to obtain wayleaves from individuals and local authorities. Therefore the New Telephone Company believe they would be right in giving up their claim to this power, as they are asked to do by Government, because the Post Office are themselves willing, in return, to give all underground facilities which would be required in municipal districts for a perfect twin-wire system, and also run inter-town trunk mains of sufficient capacity to give good telephonic service.

The New Telephone Company intend to adhere rigidly to the twin-wire system, so that every subscriber may obtain the fullest benefit from the Government trunks, and be able to communicate freely and effectually from his own office or house to the Ultima Thule of the system. The importance of such a universal service as this can hardly be over-estimated. For Press purposes, for instance, such a system will be invaluable. If there is, say, a great political meeting in the Free Trade Hall, Manchester, the reporter can telephone the speech direct to the editor's office in London as fast as the speech is delivered, and all the trouble will be saved of putting the speeches through the telegraph instruments. We have thus the great inter-town purposes served. For the municipal service every subscriber will have his own twin-wire connection to every other subscriber, and for the amount of his subscription can talk for a minute or all day if he wishes.

But further than this, the requirements of the general public will also be served by an arrangement which it is proposed shall be made between the Post Office and the New Telephone Company. Every post office will be in connection with the municipal exchange, and thus in connection with the trunk lines all over the country. At the present time, if you wish to send a telegram you have to go down to the post office, compress your meaning into a few words, and send a short telegram. Under the new arrangement you will call up the post office, who will connect you to the nearest post office to your friend's house; you will dictate your message, as long or as short as you please (paying by time, not by words), and the typewriter will type your message and the boy will deliver it exactly as a note or a letter is delivered. Everybody will therefore partake of the improved service, and not the telephone subscribers alone. At first, until some experience has demonstrated the practicability of a lower, the annual rate to subscribers for London will be £14, although the first 5,000 who join will be charged £12. 12s. only. For telephoned telegrams there may be a small extra fee. The rates for the country towns will not exceed £8 a year; and of course the public can send typewritten telegrams from the public call offices as they do now with the ordinary telegrams, with the greater advantage of not having to compress their words or pay exorbitant rates.

From the public and political point of view the Government were bound to take some action of this kind. Rightly or wrongly, they have some eleven millions of public money invested in the telegraph monopoly. If Government were not to adopt their present policy they would either have certainly to lose enormously in telegraphic business, or they must eventually be forced to buy up the telephone companies. Now against the question of purchase there are two serious objections. The first is a very practical one at this moment, that the license stipulates for the power to purchase once in seven years. The first period of seven years has already expired, and therefore will not come round again for another seven years, during which time much loss might accrue to the Government monopoly in telegraphs.

This leads to the second objection, which can only be properly seized after reading the purchase clause of the license. This clause is very badly drawn, and no one knows exactly what it is that is to be purchased if the desire were to purchase. Some two years ago Lord Salisbury was approached with the view of forcing a purchase, and Mr. Raikes also was interviewed, but it was pointed out that no definite knowledge could be gained from the clause as to what the Government would be liable to pay for. A valuer was to be appointed by each side and an impartial arbitrator, but what the arbitrator was to arbitrate upon was not stated—whether he was to adjudge the value of goodwill, capital, and so forth, or simply value of instruments, lines, and so forth as a system—so that it was quite possible the Government might be landed in the old telegraph purchase difficulty once again, and the public be made to pay three or four millions for practically nothing. This they determined not to do.

Now to go to the purely practical question of telephonic plant. It has been perfectly apparent for some time that the telephonic service would eventually cut out the telegraph. Already in the French Post Office the receipts from the trunk lines of telephones form the best-paying part of the department. This the National Telephone Company have recognised, and promptly set to work to establish trunk lines, but, unfortunately for them, their urban systems are composed of single wires, which cannot be connected to the looped trunks without considerable loss of efficiency, so that, except for comparatively short distances, patrons of the inter-town lines have to go to special offices to speak—an intolerable and, in the light of modern knowledge, an absolutely unneccessary, restriction. Besides which, subscribers on the single-wire systems have no guarantee that their most private communications are not overheard by trade rivals.

If the National Company possessed an efficient system it would have been perfectly useless for the New Telephone, or any other company, to attempt to oust them. If they had even 6,000 subscribers in London on a *satisfactory* service, it would have been hopeless. But they have not. Their 6,000 subscribers are connected to an unsatisfactory service, and when, in addition to providing better methods, the New Company are content to receive some £44,000 per annum less than is now paid by the London subscribers, it is not difficult to predict which side the victory will ultimately incline. Once established, the battle will be won: there will be no need to seek subscribers.

What must happen to the National Telephone Company under such circumstances hardly yet seems to be realised. To compete with the New Company, they would have both to reduce their rates and improve their service. If with a rate of £20 in London and £10 in the country they contrive to pay a 7 per cent. dividend on their enormous capital, it is the matter of a simple act of accountancy to see what would be the effect of reducing their rates to any acceptable extent. But in order even then to compete they must rearrange their system and use twin wires, which is as much as to say that they must take down their wires, lay new lines, and change their switchboards. This means beginning over again, with new expenditure on top of their three millions. The only chance would be to boldly write off half the present capital, and tackle the problem unhesitatingly on modern lines. Whether they will do this remains to be seen; but it is certain that the National Telephone Company can no longer occupy a masterful position, and, as of old, control the situation.

THE PYKE AND HARRIS ALTERNATE-CURRENT DYNAMO.

In last week's issue we called attention to this machine as shown at the Royal Society. The illustration represents a 100-light alternate-current dynamo on this system. The inductors are shown separately.

This machine is designed to work on the inductor principle, primarily designed by Faraday, and is claimed to embody the following advantages: The machine is very compact—the whole machine consisting of two castings, iron stampings, and coils—and is exceedingly cheap and simple to construct. Like machines worked on the inductor principle, it has the advantage of no rotating wire or sliding electric contacts; both the field and armature coils are stationary; and a further advantage is that in case of the failure of one or several of the coils, there is a fuse arrangement attached to each connection, which melts before the current from the active coils passes into the defective one.

Fig. 1 represents a vertical section, B representing the magnetic mass forming an annular space for the inducing coil and enclosing the latter on three sides. D is the inducing coil, which is surrounded with a mass of magnetic material on its inner and outer circumference and on one face, the said magnetic mass extending beyond the edge of the coil. The said face is then closed, except at a narrow zone sufficient for the rotation of the inductors, by placing on the extensions of the magnetic mass flat annular laminæ, in the form of soft charcoal iron stampings, shown in Fig. 4, arranged so as to form a continuation of the field magnet, provided with the necessary polar projections. The laminæ are rigidly fixed to one another and to the field magnet, shown in Figs. 3 and 4.

Fig. 2 is an end view, the right half being shown with the inductors and the left half without the inductors. The left half shows also some of the polar projections without the secondary coils. S represents the driving shaft, supported by the magnetic mass and carrying at one end the inductors, while at the other end is fixed the driving pulley, P. The shaft is lubricated by means of a longitudinal groove, which is supplied from a lubricator through an oblique passage, 1.

Fig. 5 is a perspective view of the inductor, which is of approximately equal breadth to the distance from centre to to centre of contiguous pole-pieces. These inductors are subject to great magnetic strains, to resist which requires extreme rigidity. The material of which the inductors are composed requires to be built of the softest iron laminæ, and the laminæ are fixed by bolts of considerable thickness with strong metal supports. These strengthening parts, placed as they usually are in a powerful magnetic field of varying intensity, are favourably situated for the generation in themselves of a considerable amount of eddy currents. One important point in Messrs. Pyke and Harris's invention consists in interleaving strengthening metal between the laminæ of soft iron which constitutes the inductor. In the present machine the inductors are placed parallel to the axis of rotation of the carrier. The principle of strengthening plates in each inductor, and the principle of soft iron plates between the pair of strengthening plates, of course varies according to requirements. The plates are separated from each other by thin sheets of paper as is usual, steel sheets being used for the strengthening laminæ.

Fig. 6 is a section, and Fig. 7 a face view of one of the reels carrying the secondary coils. The inductor carrier, which is of gunmetal, is represented by C, Fig. 1, mounted on one end of the driving shaft, S. Electric currents are produced by revolving the magnetic inductors in proximity to the magnet, which is provided at both poles with polar projections, serving as cores for the conductors in which the current is to be induced, the object of the inductors being to complete the magnetic circuit alternately through each set of polar projections. An even number of polar projections are employed, and the revolving inductors are arranged so that in proportion as one pole is being demagnetised the magnetism of the other pole increases, and *vice versâ*, thus the total magnetic effect being always approximately constant. The induced current conductor is so arranged that the polar projections which are being magnetised and those which are being demagnetised have a similar inducing action upon it, the magnetising of one set of polar projections thus increasing the effect produced on the same wire by the demagnetisation of the other set of polar projections.

This invention may be used in machines for the production of single or many phase alternating, or for continuous currents, the polar projections and the induced current conductors being readily arranged for any desired disposition (in the case of inductor machines being so arranged that the induced current conductor may be wound on the polar projections).

Fig. 1.

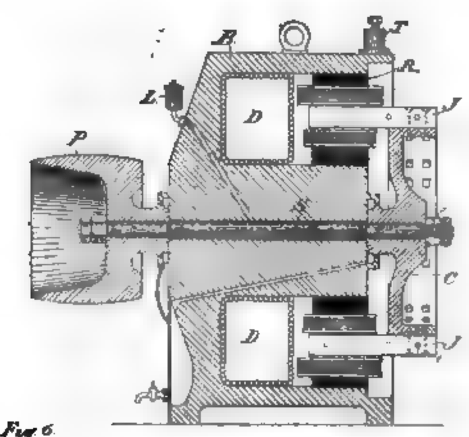


Fig. 2.

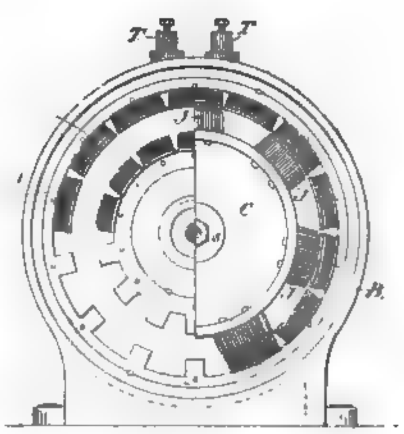


Fig 6

Fig 7

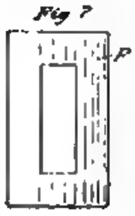


Fig 3

Fig 4

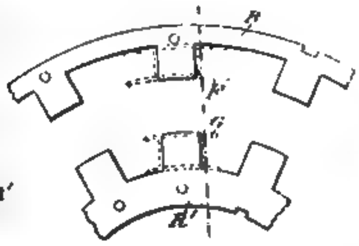
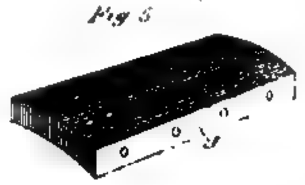


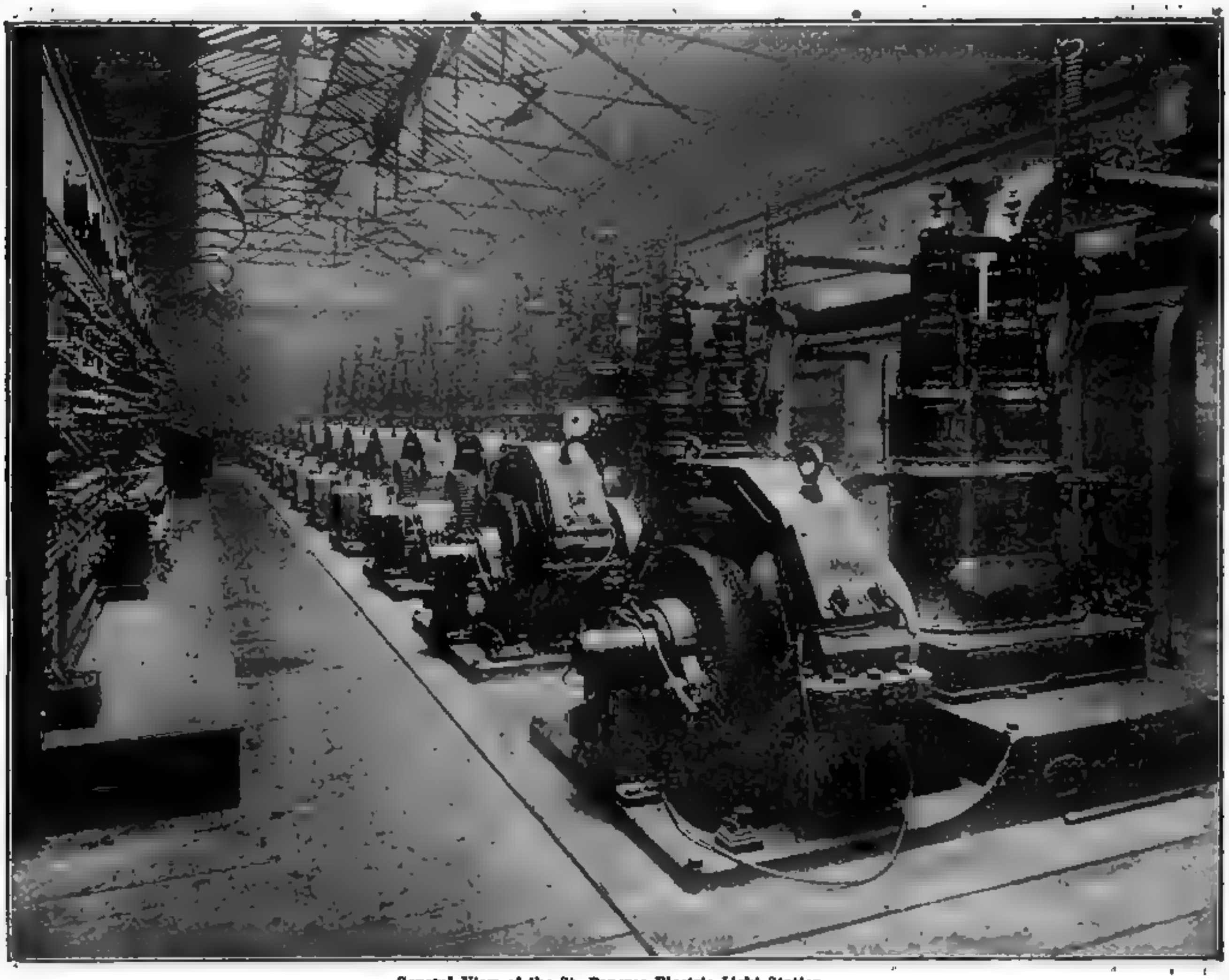
Fig 5



ST. PANCRAS ELECTRIC LIGHT STATION.

The accompanying engraving represents a general view of the Regent's Park station, which we referred to in our leader of the 29th ult. It will be seen that there are 11 engines and dynamos known as the Kapp-Willans combination.

The engines are of Messrs. Willans and Robinson's latest and improved triple-expansion type, and the dynamos are Johnson and Phillips's well-known central station multipolar type, manufactured by that firm at Charlton, Messrs. Johnson and Phillips being the owners of Mr. Kapp's patent. They are similar to the large eight-pole machine which is causing much attraction at the Crystal Palace (see *Electrical Engineer*, April 15th). The present machines, however, have six instead of eight poles.



General View of the St. Pancras Electric Light Station.

Of these 11 dynamos, which are all continuous current, six are wound for an output of 680 amperes at a maximum of 130 volts, for supplying current to the street mains; three are wound for an output of 680 amperes at a maximum of 145 volts, for supplying current to the street mains, or for charging accumulators. The above nine machines are shunt wound, and are each supplied with a switch by means of which they can be worked self-exciting or separately excited, and are arranged for delivering current on the three-wire system. The compactness of the combination is amply shown by the fact that each steam dynamo of 90 kilowatts output only requires an area of 10ft. 6in. by 5ft. 6in. of floor space, a factor of the greatest importance in central station works. At the official trial at Thames Ditton, the above combination showed a consumption of steam equal to 18·65lb. per electrical horsepower per hour, when working on the condenser.

The remaining dynamos are wound for an output of 90 amperes at a maximum of 580 volts for supplying current to the Brockie-Pell arc lamps in Tottenham Court-road and Euston-road, or for charging in series four sets of 60 secondary batteries at the central station. These dynamos are separately excited from the low-tension circuit. At the official trial of this combination the steam consumption was equal to 19·6lb. per electrical horse power per hour.

At present there are only 28 arc lamps in use, which are worked in four parallels of seven in series, but it is likely that these will shortly be increased to 90, and would be worked in nine parallels of 10 in series, thus taking up the load of one dynamo, the other one being held in reserve. The lamps already installed are of the Brockie-Pell double-carbon new 32-hour type, being specially designed for street work; each lamp is erected on an ornamental cast-iron post, at a height of 25ft. from ground level to centre of arc, at distances varying from 160ft. to 245ft. apart along the middle of the road. In a chamber, at the base of each post, a double pole switch, mounted on an oil insulator, is fitted, which switch allows of any lamp being cut out of circuit without interfering with the current of the other lamps whilst that particular lamp is being trimmed during foggy weather, or for any other reason when it may be required to cut out a lamp. Alternate lamps are put on different circuits, so that at midnight, or at any specified time, half of the lamps can be switched out at the central station, leaving the intermediate lamps still in circuit.

The whole of the works have been designed and carried out by Prof. Henry Robinson, M.Inst.C. and E.E., Westminster.

Kansas Electric Railway.—An electric elevated railway is to be established at Kansas City, Kansas, the Elevated Railway Company having been granted an ordinance permitting it to operate its line by electricity instead of steam.

THE

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ELECTRICITY AND SANITATION.

Some three or four years ago a scheme was put forward by Mr. Webster, at a meeting of the British Association, to attempt the solution of one of the sanitary problems of the day by employing electricity. Experiment showed that the suggestion was feasible, but the question of cost was not so easily settled. Possibly it is due to the cost that we have heard little or nothing of the method since. Quite recently, at the meeting of Municipal and County Engineers at Nottingham, one gentleman during the discussion of papers expressed wonder that factories should be allowed to empty their waste products into the sewers without any attempt at purification. He thought that at any rate these products should be partially purified before having to be dealt with wholly at the ratepayers' expense. It seems to us that this wonderment is quite natural, and it really is inconceivable that factories should be allowed to get rid of their waste products at the public expense. If a steam engine is used, the local authorities make a charge for carting away the ashes, but no such charge is made for taking away and purifying the water, say, from a dye works. The getting rid of the ash refuse is rightly considered a charge upon the manufacturer, but the contamination in the liquid refuse is not looked upon as being chargeable to the manufacturer for purification, but is a charge saddled upon the rates. This refuse—which, as we say, in very many instances passes direct into the sewers, as indeed we believe it does at Nottingham—is taken perhaps miles away to the sewage farm, treated, and the effluent from the farm is expected to be practically pure water, free from all contamination. We may roughly assume that, during its passage from the sewage carriers to the effluent, the water has undergone a process of filtration through the soil into the drains, and another process of oxidation. We have long since pointed out that Webster's process of purification is but a hurrying of Nature by artificial means. He puts electrodes in his liquid sewage, generates large quantities of oxygen, and so brings the oxidisable matter into contact with free nascent oxygen in a very short space of time, whereas Nature might take days, or even weeks, in the process. The operation is none the worse for being hurried, and the result is exceedingly satisfactory. Now, cannot the Webster process be applied to the waste liquid products of factories before these waste products are allowed to enter the sewers? If so, instead of having to deal with contaminated liquid at the expense of the ratepayers, no doubt it would be possible to pass the purified liquid through the surface drains, and let it run direct to the waterways without further treatment. This would considerably assist the drainage system of towns, and the cost of sewage treatment. The general rate would still provide the channels through which the waste liquids would pass, but these would not have to be submitted to chemical or sewage farm treatment. The only objection to any scheme of the kind is that manufacturers who hitherto have had no charge for purification of waste would be subjected to such a charge. Naturally, they would prefer to

continue in the old ways, which cost them nothing, rather than to fall in with a system that put extra, though perfectly just, charges upon their shoulders. The question, however, is one that affects the whole of the community of ratepayers, and as the incidence of rating is becoming more and more keenly felt, depend upon it there will arise a general demand that those who make the contamination should pay for the purification. That the efficacy of a continuous current of electricity would under most circumstances be perfectly satisfactory can hardly be denied, and here, again, is another direction where, sooner or later, central stations will be required to supply a demand. Gradually, but surely, ways will be opened for the machinery to be kept working at full loads, but, unfortunately, many of those engaged in the industry are so enamoured of the thing that is—that is, the supply of current for light—that they ignore all other considerations. Perhaps, however, it is as well it is so. They have to sell what they make, and will make the apparatus necessary to supply any demand. So we trust to the gradual enlightenment of municipal engineers, rather than to the soft-spoken words charmingly uttered of the would-be installer of a central station. The municipal engineer has to look forward to the demand of to-morrow as well as to that of to-day, and he is gradually becoming familiar with facts that will enable him to make provision for the future. He is wise.

ELECTRIC AND CABLE RAILWAYS.

The success—and by this we mean the commercial success—of the South London Electric Railway being fairly assured, it was but natural that engineers and capitalists should look around for new fields of work and investment. We say the commercial success of the South London line is fairly assured; from our point of view it will not be absolutely assured till the receipts average a thousand pounds a week, but an examination of the weekly returns as given in our columns will show the receipts to be gradually and continuously creeping upwards towards this amount. If, then, a line which was costly, which was to a large extent experimental, which has no feeders, and which can hardly be said to run through the best paying districts, has reached so favourable a position within a couple of years of its opening, it may be expected that other similar lines more favourably situated will reach the paying point in a shorter time. Thus, various lines were projected, and to consider these a Joint Committee of Lords and Commons is sitting. It will be quite out of place to consider the evidence before their report is issued, but we can hardly do wrong in calling attention to the action of the London County Council. The Parliamentary Committee of the Council has formulated certain resolutions on the subject, which the Council has practically adopted. These resolutions will probably be pressed upon the Joint Committee, and thus may be said to be *sub judice*. It is not with these, then, we deal, but with a definition that these electric railways are merely underground tramways, and having thus defined the works, it is contended that they should come under the jurisdiction of the County Council just like other tramways. But is the definition correct? One of the broad distinctions between a tramway and a railway, in this country at any rate, is that a tram stops and starts whenever and wherever a passenger desires to get on or off, whereas a railway stops at and starts from fixed points only. There are many men among us disposed to look even upon the South London line as merely a miniature of what is to be. They expect in the near future the ordinary locomotive to make way for the electric motor, and that steam will be as quickly superseded by electricity as coaches were by trains. If their expectations come to pass, the County Council will have to deal with railways and not tramways. They are going for compulsory purchase because of the definition "underground tramways," forgetting or ignoring that these tramways will, if the above views are correct, develop into more substantial works. Why should the County Council monopolise tramways, and not cabs, 'buses, and bicycles? Surely one method of locomotion is not more important than another, and we fail to see any reason that can be put forward for compulsory purchase of tramways that is not as conclusive for the compulsory purchase of 'buses. We apprehend that if the existing electric railway should prove an absolute commercial success, and if the proposed railways are constructed and prove successful, extensions will undoubtedly take place, and circular systems joining all points of the compass will be developed, and approximate more and more to the ordinary railroad. Electricity and steam traction may exist side by side, yet we may be allowed to doubt this for underground work. The Metropolitan and Extension Railways may ere long elect to try electricity, and, if so, will these be dubbed underground tramways, and come within the powers the County Council wish to acquire for compulsory purchase?

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE PROPOSED BOARD OF TRADE UNIT.

SIR,—The Board of Trade had kindly wished to adopt the name "kelvin" for the "Board of Trade unit," and had taken the necessary preliminary steps for introducing it into the provisional order for this year. But I have pointed out some reasons why this should not be done; and I am permitted to say that the provisional order will not introduce any new name.

It seems to me that the difficulty which has been felt in the cumbrousness of the name "Board of Trade unit" will be obviated wholly and in the most simple manner by using "supply unit" to denote the particular unit defined by the Board of Trade for the reckoning of electric supply. Thus, supply meters, by whomsoever invented, will give their readings in supply units. Ordinary householders, who know nothing of ergs, of meg-ergs, of joules (though knowing the name and something of the work of Joule), of watt-hours (though all know James Watt), will naturally use the simple word "unit" in checking and paying their electric lighting accounts. In scientific statements the double word "supply unit," with only four more letters than "kelvin," will perfectly distinguish the particular unit intended from all others.—Yours, etc., KELVIN.

6, Cadogan-place, S.W., May 6.

THE CHICAGO EXHIBITION.

Prof. Elisha Gray, who is now on this side of the Atlantic, asks us to give publicity to the following relating to this exhibition :

Preliminary Address of the Electrical Committee.

"It is eminently fitting that at suitable times and on suitable occasions men in all departments of science and industry should come together for interchange of thought, and for the discussion of subjects that have to do with the great activities of life—practical and intellectual. What more fitting time to hold a series of congresses than during the great World's Columbian Exposition, at Chicago, in 1893? In pursuance of this object the World's Congress Auxiliary of the World's Columbian Exposition has been organised, under the support of the Exposition Corporation, and has been recognised and approved by the Government of the United States. Under this organisation committees have been appointed to organise a series of congresses. Among others, a general committee, consisting of a local committee and an advisory council, selected from men eminent in the science both in this and in foreign countries, has been appointed by the World's Congress authorities to organise a World's Electrical Congress, to be held at Chicago sometime during the summer of 1893. The movement is, as yet, in a formative stage, and much thought must be given to it before a detailed programme can be formulated. It is the intention of the General Committee to so organise the congress that the greatest good to the science and to all interested in electrical progress may be attained. It is desirable that the work of the congress should be dvided into sections, the number of which will be determined after consultation with the advisory council. The first and most important section should give its time and thought to the more purely scientific phases of the subject, such as the revision of the existing electrical units, and the addition of such others as the state of the science may require Other sections should be devoted to the more practical questions of applied electricity. In addition to the meetings of the various sections, there will be general meetings, where all will come together to listen to papers from men eminent in the science from all parts of the world. An audience-room will be furnished, where such general meetings of the congress will be held, in connection with which will be smaller rooms, suitable for the meetings of the various sections. In order that their conclusions may have the authority both of scientific ability and of official sanction, the members of the first, or scientific section, should be appointed by the respective Governments from which they come. The delegates having this very important work in charge should represent the best talent from all parts of the world, or from such countries as, by reason of achievements in the domain of electricity, are entitled to a voice. We invite the hearty co-operation of all persons interested in electrical progress, not only by any suggestions they may have to make, but also by their presence at their congress in 1893. Already there is a lively interest felt in the matter, in this and other countries, for the idea of holding an Electrical Congress, at the time of the World's Fair, is not a new one either to European electricians or to the profession in this country. Several associations of electricians have suggested it; for three years past the American Institute of Electrical Engineers has had an active committee on this subject; and at the Electrical Congresses of Paris, 1889, and Frankfort, 1891, its delegates extended a formal invitation to their European associates to come to America in 1893. Since those invitations were extended, the present authorities have been appointed by the World's Congress Auxiliary of the World's Columbian Exposition. When these authorities presented the matter officially to the institute, they immediately saw the fitness of having the congress held under the auspices of the World's Fair, and by a formal and unanimous vote of its Council and Special Congress Committee, it has pledged itself to give all possible support to the agencies now entrusted with the responsibility of making a success of the proposed Electrical Congress, at Chicago, in 1893. It is the hope and expectation of the Committee on the Electrical Congress that other electrical associations at home and abroad will give us the same hearty co-operation. The time of meeting will be most auspicious, as the representatives of the world's best thought and best work will be centred here, and the congress will meet under the shadow of the greatest palace of electricity the world will ever have seen. Other announcements will follow this one, from time to time, as the work of organisation goes on. A partial list of the advisory council of this committee is appended. All communications in the way of suggestion or otherwise should be addressed to the chairman."

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 440.)

A most curious feature of alternate currents of high frequencies and potentials is that they enable us to perform many experiments by the use of one wire only. In many respects this feature is of great interest. In a type of alternate-current motor invented by me some years ago, I produced rotation by inducing, by means of a single alternating current passed through a motor circuit, in the mass or other circuits of the motor, secondary currents, which, jointly with the primary or inducing current, created a moving field of force. A simple but crude form of such a motor is obtained by winding upon an iron core a primary, and close to it a secondary coil, joining the ends of the latter and placing a freely movable metal disc within the influence of the field produced by both. The iron core is employed for obvious reasons, but it is not essential to the operation. To improve the motor, the iron core is made to encircle the armature. Again to improve, the secondary coil is made to overlap partly the primary, so that it cannot free itself from a strong inductive action of the latter, repel it its lines as it may. Once more to improve, the proper difference of phase is obtained between the primary and secondary currents by a condenser, self-induction, resistance, or equivalent windings. I had discovered, however, that rotation is produced by means of a single coil and core; my explanation of the phenomenon, and leading thought in trying the experiment, being that there must be a true time lag in the magnetisation of the core. I remember the pleasure I had when, in the writings of Prof. Ayrton, which came later to my hand, I found the idea of the time lag advocated. Whether there is a true time lag, or whether the retardation is due to eddy-currents circulating in minute paths, must remain an open question; but the fact is that a coil wound upon an iron core and traversed by an alternating current creates a moving field of force, capable of setting an armature in rotation. It is of some interest, in conjunction with the historical Arago experiment, to mention that in lag, or phase, motors I have produced rotation in opposite direction to the moving field, which means that in that experiment the magnet may not rotate, or may even rotate in opposite direction to the moving disc. Here, then, is a motor (schematically illustrated in Fig. 17), comprising a coil and iron core, and a freely movable copper disc in proximity to the latter. To demonstrate a novel and interesting feature, I have, for a reason which I will explain, selected this type of motor. When the ends of the coil are connected to the terminals of an alternator, the disc is set in rotation. But it is not this experiment, now well known, which I desire to perform. What I wish to

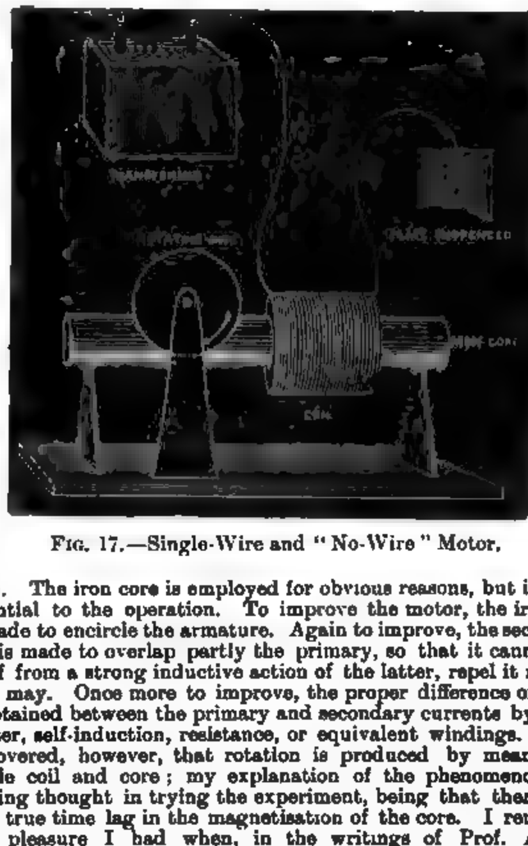


FIG. 17.—Single-Wire and "No-Wire" Motor.

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

show you is that this motor rotates with one single connection between it and the generator; that is to say, one terminal of the motor is connected to one terminal of the generator—in this case the secondary of a high-tension induction coil—the other terminals of motor and generator being insulated in space. To produce rotation it is generally (but not absolutely) necessary to connect the free end of the motor coil to an insulated body of some size. The experimenter's body is more than sufficing. If he touches the free terminal with an object held in the hand, a current passes through the coil and the copper disc is set in rotation. If an exhausted tube is put in series with the coil, the tube lights brilliantly, showing the passage of a strong current. Instead of the experimenter's body, a small metal sheet suspended on a cord may be used with the same result. In this case the plate acts as a condenser in series with the coil. It counteracts the self-induction of the latter and allows a strong current to pass. In such a combination, the greater the self-induction of the coil the smaller need be the plate, and this means that a lower frequency, or eventually a lower potential, is required to operate the motor. A single coil wound upon a core has a high self-induction; for this reason principally, this type of motor was chosen to perform the experiment. Were a secondary closed coil wound upon the core, it would tend to diminish the self-induction, and then it would be necessary to employ a much higher frequency and potential. Neither would be advisable, for a higher potential would endanger the insulation of the small primary coil, and a higher frequency would result in a materially diminished torque.

It should be remarked than when such a motor with a closed secondary is used, it is not at all easy to obtain rotation with excessive frequencies, as the secondary cuts off almost completely the lines of the primary—and this, of course, the more the higher the frequency—and allows the passage of but a minute current. In such a case, unless the secondary is closed through a condenser, it is almost essential, in order to produce rotation, to make the primary and secondary coils overlap each other more or less. But there is an additional feature of interest about this motor. It is, namely, not necessary to have even a single connection between the motor and generator, except, perhaps, through the ground; for not only is an insulated plate capable of giving off energy into space, but it is likewise capable of deriving it from an alternating electrostatic field, though in the latter case the available energy is much smaller. In this instance one of the motor terminals is connected to the insulated plate or body located within the alternating electrostatic field, and the other terminal preferably to the ground. It is quite possible, however, that such "no-wire" motors, as they might be called, could be operated by conduction through the rarefied air at considerable distances. Alternate currents, especially of high frequencies, pass with astonishing freedom through even slightly rarefied gases. The upper strata of the air are rarefied. To reach a number of miles out into space requires the overcoming of difficulties of a merely mechanical nature. There is no doubt that with the enormous potentials obtainable by the use of high frequencies and oil insulation luminous discharges might be passed through many miles of rarefied air, and that, by thus directing the energy of many hundreds or thousands of horse-power, motors or lamps might be operated at considerable distances from stationary sources. But such schemes are mentioned merely as possibilities. We shall have no need to transmit power in this way. We shall have no need to transmit power at all. Ere many generations pass, our machinery will be driven by a power obtainable at any point of the universe.

(To be continued.)

THE BRISTOL TENDERS.

We understand the following tenders were received for the Bristol work. It will be remembered that tenders were asked for (1) Supply, delivery, and erection of steam alternators and steam dynamos. For this part of the contract the following firms tender:

	£	s.	d.
Ferranti (alternators only)	£12,687	0	0
Siemens Bros. (accepted)	14,011	0	0
Clark-Muirhead	14,053	0	0
Woodhouse and Rawson	14,327	0	0
Johnson and Phillips	14,357	0	0
Crompton and Co.	15,141	0	0
Mather and Platt	15,434	0	0
Paterson and Cooper	15 826	0	0
Blakey-Emmott	15,954	0	0
Electric Construction Company	16,175	0	0
Brush Company	19,495	0	0
Goolden and Co.	20,087	0	0
India Rubber Company (continuous only)	21,090	0	0

2. Supply, delivery, and erection of boilers and accessories.

	£	s.	d.
Tucker Bros. (accepted)	7,300	0	0
R. Taylor and Sons	7,504	0	0
Yates and Thom	7,665	0	0
Oldham Boiler Works	8,060	0	0
Woodhouse and Rawson	8,063	10	0
Fraser and Fraser	8,614	0	0
Newall and Co.	8,999	9	6
J. Thompson	9,500	0	0
Hawksley, Wild, and Co.	9,723	0	0
E. Finch and Co.	10,500	0	0

NOTES ON THE LIGHT OF THE ELECTRIC ARC.*

BY ALEXANDER PELHAM TROTTER, B.A., MEMBER.

(*Concluded from page 427.*)

By permission of Mr. Inglis, secretary to the Trinity House, the author was allowed to examine the working of the St. Catherine's Point Lighthouse at the beginning of the present month, and to have the machinery run during the daytime. The magneto machines and lamps are the same that were used at the South Foreland in 1884 and 1885. Alternating currents from 180 to 300 amperes are used; the volts at the lamp are only about 35 to 38. Sir James Douglass's fluted carbons, of 50 mm and 60 mm. diameter, are used, the smaller size being employed during clear weather. They have a graphite core. The conditions are altogether different from the continuous-current arc which has been described. It was found during the South Foreland experiments that a short arc gives more light than a long one. It must be remembered that the horizontal light is the most useful, although in a large lantern a considerable angle is utilised by the lenses. A large alternate-current arc is very unsteady, the flame burns away the carbon in a very irregular manner, and when round carbons were used a hollow crater was formed at the end of each. The walls of the crater would give way, and cause great variation in the light. By the use of fluted carbons little, if any, hollowing takes place, and the light is more uniformly emitted. It seems probable that since each carbon is only at a high state of incandescence during half a period, a short arc gives more light because the carbons keep each other warm. The same amount of radiant energy may be given off with a long arc and a short one, but when the chilling of the negative is reduced a greater proportion of the radiation will be in the form of light. With a long alternating arc the flame wanders round, and is blown violently sideways, and the crater therefore tends to be shifted to one side of the carbon. The distance between the carbon is only $\frac{1}{16}$in. to $\frac{1}{8}$in., and as they are by no means flat it is the exception that any interval can be seen between them.

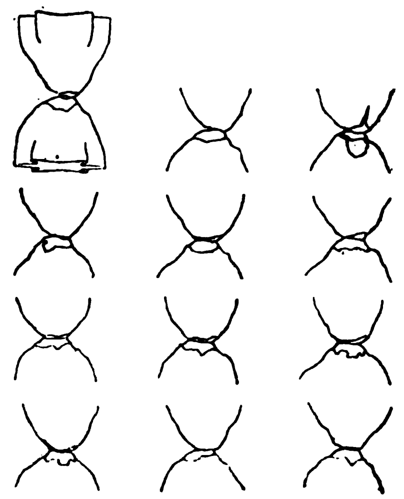
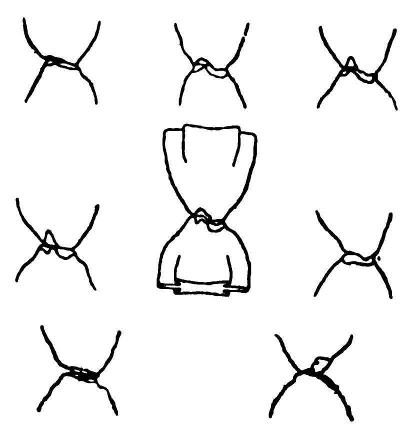


FIG. 8.



FIGS. 9 AND 10.

The author understood that an optical apparatus was provided for projecting the image of the arc on the side of the lantern, for the purpose of keeping the carbon points in the focal plane of the lenses. He found no such instrument was in use at St. Catherine's Point, but a very satisfactory image was thrown by the object-glass of a telescope. The distances were arranged so that the image was full size. The shape changed so quickly that

* Paper read before the Institution of Electrical Engineers.

it was impossible to draw the image with great accuracy, and attention was paid only to the outline of the carbons and of the crater. The outlines in Fig. 8 are reproduced from a series of tracings made at intervals of half a minute. Fig. 9 is an interesting set, showing the gradual development and disappearance of an irregular interlocking of the two carbons. This does not appear to have any connection with the flutings of the carbons, and the author has noticed it on several occasions, both at the lighthouse at the recent Naval Exhibition and at St. Catherine's Point. A glance at these tracings shows that only a very small portion of the true light-giving surface is visible, owing to the shortness of the arc. Fig. 10 is a pair of tracings showing the most regular and the most irregular form of crater.

The areas of the crater on the tracings were measured by a planimeter, the tracing point being taken 10 times round. The mean area of Fig. 8 is 0·2087 square inch, and the mean of Fig. 9 is 0·146 square inch. The interlocking form of crater appears, therefore, to give about 30 per cent. less light. The candle-power for 240 amperes, according to the measurements made at the South Foreland in 1884 and 1885, is about 16,000 c.p., giving about 75,000 candles per square inch if the light were entirely due to the crater. The area of the yellow and orange coloured parts of the carbons was very difficult to estimate, but it was very much greater in proportion to the true crater than in a continuous-current lamp taking 10 to 20 amperes. Taking these parts as exposing about four times the area of the crater, and giving one-eighth of the light per square inch, the crater alone may be taken as given two-thirds of the whole, or about 50,000 candles to the square inch. This agrees fairly well with the result already given for the measurements at Finsbury.

It was found during the South Foreland experiment that 40 mm. cylindrical carbons became red-hot throughout their whole length when 300 amperes were passing. The fluted carbons, measuring 60 mm. over, have a sectional area equal to that of a cylinder about 46 mm. diameter—that is, 2½ square inches; but the cooling surface is about 50 per cent. greater. Larger carbons would probably burn yet more irregularly, and yet it seems very desirable to increase the light during foggy weather. If the ends of the carbons could be maintained conical, all the light-giving surface would be usefully employed. A carbon which is more and more refractory towards the centre suggests itself; but even at present the consumption is from 1½ to 2½ inches per hour, and modification can only be made in the direction of less refractory material. The flame might be made to spin round the carbons under the influence of a magnetic field; but the simplest plan seems to be the revolution, or gyration, of the carbons about a common axis, their centres being slightly displaced. In order to obviate sliding contacts, a gyratory motion would be the best. The power of the St. Catherine's Point lighthouse has been called 6,000,000 to 7,000,000 c.p. This would require an area of crater of about one square foot.

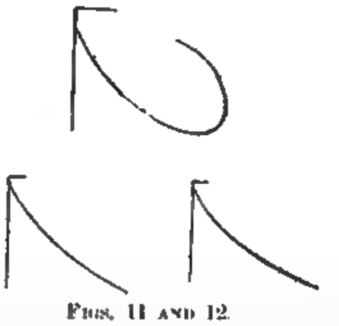
The following measurements of red and green light from different sources have been made by Prof. L. Weber, of Breslau, taking incandescent platinum as unity. Taking the Violle platinum unit at 18·5 standard candles, the author has converted them into candles per square inch and candles per square centimetre, and has added six other sets, with white light only, from his own observations.

—	C.P. per sq. in.		C.P. per sq. cm.	
	Red.	Green.	Red.	Green.
Platinum (Violle standard) ...	120	120	18·5	18·5
Sun's disc	487,000	1,000,000	75,500	155,000
Sky, near sun	120	120	18·5	18·5
Albo-carbon on edge	73·5	60·7	11·4	9·4
White paper, horizontal, exposed to summer sky, noon	16·5	35·2	2·56	5·45
White paper, sun 60 deg. high, paper facing sun ...	8·25	17·2	1·28	2·67
Albo-carbon flat	10·5	8·7	1·63	1·35
Argand	6·8	5·24	1·05	0·82
Black velvet, summer sky, noon	C·0338	0·07	0·0052	0·0109
White paper, reading without straining	0·0018	0·0024	0·00028	0·00037
	White.		White.	
Sperm candle	2		0·31	
Moon, 35 deg. above horizon...	2		0·31	
,, high	3		0·46	
Batswing (whole flame).......	2·25		0·35	
Methven standard	4·3		0·666	
Crater of electric arc	45,000		7,000	

The foregoing considerations about continuous-current arcs point to the value of a long arc, a small, and if possible a pointed, negative carbon; but these must without hesitation be sacrificed to perfect steadiness. For outdoor work the uniformity of distribution is not much affected by the shadow of the lower carbon. Indeed, it may perhaps be advantageous, for there is a fair amount of stray light immediately beneath an arc lamp, and if the lower carbon could be dispensed with there would be an overpowering illumination, which would make street lighting much more irregular than at present unless very high posts were used. But for railway stations, and for such places as the British Museum reading-room, some improvements might be made in this direction. Experiments have been made with a carbon rod surrounded by a carbon tube, arranged pointing downwards, and the arc has been made to travel round by magnetic rotation. The rod should be positive, as the end surface of the tube would be too large to keep incandescent unless with a very large current. The Jamin candle, a modification of the Jablochkoff, and the Rapieff and Hedges lamps, are examples of efforts in this direction.

Several attempts have been made to improve the arc by adding volatile substances, or by introducing gas through a hollow carbon. The most successful of these appears to have been the Saunderson method of using hydrocarbon by means of a wick, but nothing has been heard of this for some time. The only good effect that can be expected is the production of a long arc which will reduce the shadow of the lower carbon; and it is likely that the temperature of the crater will be reduced by the presence of any substance less volatile than the best carbon.

With a scientific but misguided regard for truth, the candle-power of arc lamps has been reduced to its "mean spherical" value by many authorities. An easy way to arrive at this is to cut out a piece of card to the shape of a candle-power diagram, such as Figs. 1, 2, or 3. By balancing this on a pencil, on a line parallel with the perpendicular axis, the distance of the centre of gravity from the axis may be found. The area may be measured with a planimeter, or by comparing the weight of the card with that of the rectangle out of which it was cut, or by treating the curve as being composed of half an ellipse and part of a parabola.* Then, measuring the distance of the centre of gravity from the axis, and multiplying this by 2 π times the area, the solid contents of the figure of revolution of the curve about its axis are obtained. The mean spherical candle-power of the arc is equal to the radius of a sphere having the same solid contents. As so little light is emitted above the horizontal, it would seem quite as useful to take the mean hemispherical candle-power. But we not only learn nothing fresh, but are likely to be misled, for a light giving the same mean spherical candle-power would not be nearly so useful as an arc. The mean spherical candle-power has been found by M. Rousseau by plotting to rectangular co-ordinates.† But the method is not much easier, and it seems better to retain the polar curve, which has a geometrical meaning.



FIGS. 11 AND 12.

Since there is little or no difference in the light-giving properties of arc lamp carbons, the various qualities differing mainly in homogeneity and rate of burning, and since there must be a definite relation between the watts expended and the area of the crater, or the candle-power, it seems preferable to denominate the size of arc lamps by the number of watts expended. There is no reason why the maximum candle-power at the best angle should not be given, if the candle-power be mentioned at all; but the carbons should be very carefully centred, and the test should be made either with several photometers simultaneously, or with a lamp revolving like a meat-jack. The nominal 2,000 c.p. which 10-ampere arc lamps are sometimes supposed to give is a perfectly unjustifiable convention, and has been very properly characterised as "a fine old crusted lie."

It might be imagined that, since an ordinary opal globe surrounding an arc lamp does not appear to differ greatly from a uniformly luminous sphere, the candle-power at different angles would be very much more uniform. This is not the case. Fig. 11 has been derived from the measurements of the illumination on the surface of the street by an arc lamp in Cornhill, an opal globe being used; the dotted line is assumed. Fig. 12 is a pair of similar curves, derived from measurements made in Queen Victoria-street with arc lamps enclosed in moulded glass.

Owing to the difficulty of comparing the light from an arc lamp with the light of a candle, on account of the difference of colour, it has been a common practice to make photometric measurements with red and with green glasses, and elaborate tests have been made by Prof. Nicol and others throughout the whole range of the visible spectrum. The red and green glasses allow rather more definite readings to be made; but by a little practice with a photometer, which allows very free and rapid changes to be made by the oscillation of a lever or a handle, very much greater accuracy may be obtained than with an instrument in which a screen or a lens has to be moved on a slide until a balance is effected. But the green and red measurements having been taken, no one has yet suggested what is to be done with them; neither the mean, the sum, nor the product has any physical meaning, and the two readings are generally given side by side. For purely scientific work, where the light is treated as radiant energy, either the whole spectrum should be

* Area of ellipse = minor axis × major axis × π/4. Area of parabola = base × ⅔ height.

† Eric Gerard, "Leçons sur l'Electricite," vol. ii., p. 298.

measured and compared with a standard, or the luminous rays should be carefully separated from the dark heat rays, and the radiation measured as a whole. Such measurements have been made by H. Nakano and by Louis B. Marks,[*] and form a very valuable contribution to our knowledge of the efficiency of the arc.

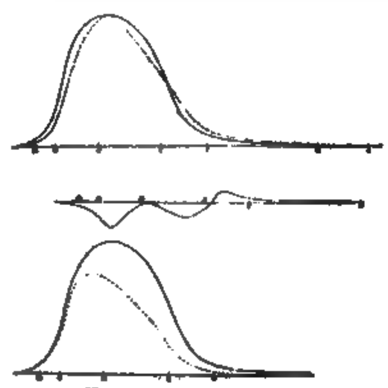
It has been shown by M. A. Crova[†] that the portion of the spectrum lying near $\lambda = 582$ gives a true measure of the total candle-power of a light. Prof. E. L. Nichols[‡] finds $\lambda = 600$ to be the position. For a considerable range of temperature the ratio between the intensity of this part of the spectrum is practically identical with the ratio of the candle-power of two lights.

The use of the green and red measurements, besides facilitating the work of the photometrist, is to compare, in a rough way, the whiteness of the light under observation with a standard light. The measurements of M. de Nerville[§] afford some information as to the colour of the arc lamps at the Hippodrome, the glow lamps at the Opera House, and the gas lighting at the Post Office at Paris. But this information can be obtained only in the arbitrary terms of the ratio of the red reading to that taken with the green, when these two are equal, and the ratio is unity. This was the case with the Edison lamps at the Opera House, but it tells us nothing. A complete luminosity curve for each glass throughout the spectrum would be required to explain these readings; but even then the resultant luminosity curve could not be derived. Some idea of the quality of the light thus measured may be determined by comparing the ratio of the red and green components of some standard light. Such a comparison may be made with measurements made by M. de Nerville on the illumination produced by bright sunlight shining on a window with white blinds. The ratio of green to red in this particular photometer was about 3·5 to 1 for sunlight at four o'clock in the afternoon of May 1, 1890.

Captain Abney has made many investigations on the colour of daylight, and a chapter is devoted to this in his popular book on colour measurement and mixture. In searching for a standard light of uniform colour he found nothing to equal that which is given from the crater of an arc. This is very satisfactory to electrical engineers, but it gives no definite information as to the real quality or degree of whiteness of the light. The popular idea, and one which is very firmly fixed, is that arc lamps give a bluish light, sometimes rather violet; that it shows up certain colours in a sickly or unnatural manner; and there is a widespread belief that it not only acts injuriously on the complexion, but pierces cosmetic embellishments. These ideas are of so serious a nature that the author ventures to discuss the quality of the light of the electric arc; since, although it is not a strictly electrical matter, it has a rather important aspect, in so far as it is a more or less unpopular feature of electric lighting.

The only standard of pure white light which we have is that of the diffused light of a summer day. Artists are familiar with the fact that direct sunlight is yellowish,[‖] even on the clearest days; and that a blue sky, on the other hand, gives distinctly blue light; and that both of these must be avoided, or a picture painted under such lights will appear too cold or too warm when hung in a diffused light. Captain Abney has found that at different seasons of the year and at different times of the day very considerable changes occur in the colour of sunlight, owing to the absorption of bluish light by the atmosphere. It does not, however, appear impracticable to the author to fix on a fairly typical degree of whiteness, such as that of chalk, whiting, or alumina exposed to diffused light in summer-time. A luminosity curve of the spectrum of such light would be a standard. Compared with such a white, or, indeed, by a very rough comparison with ordinary daylight in clear weather, the arc gives a distinctly pale primrose light, rather warmer than straw-yellow, and, to the author's eye, distinctly yellowish, in spite of the pale violet flame of the arc, which with inferior carbons occasionally flares up at irregular intervals. It is no use telling an unscientific person that the light is not blue, but pale yellow. He will answer, "It appears to me to be blue or violet, and therefore to me and to 99 people out of a 100 it is blue or violet.

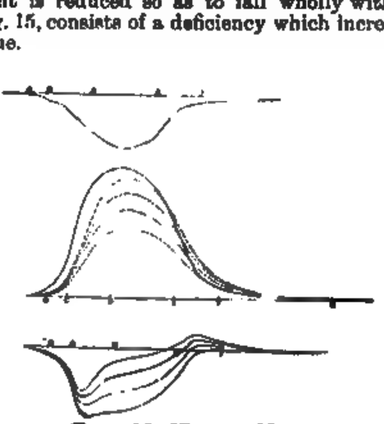
Three reasons can be brought forward to explain this optical illusion. After dusk we are accustomed to the use of strongly yellow and even orange-coloured light of gas, lamps, candles, or glow lamps, and our own idea of whiteness is lowered. The whitest thing that we can see is a sheet of white paper, which is, of course, no whiter than the yellow light of the lamps. We imagine that it is white, and thus a false standard of white is obtained. When a really whiter, though not perfectly white, light is introduced, it naturally seems to be bluish compared with the false standard of white. Whether our idea of white really becomes altered is a psychological question which it would be out of place to discuss in the present paper. Secondly, after dusk the blue-seeing nervous elements of the eye (on the Young-Helmholtz theory) are allowed to rest, while most of the work falls upon the red and green-seeing elements. These latter become wearied, while the former are in a more highly receptive condition than during the day. As soon as a light containing a tolerable proportion of blue light is seen, it naturally appears to be more blue than white. The third suggestion is based upon a result of Captain Abney's researches, which show that for the most feeble illuminations no colour can be distinguished, and that the first colour which can be discovered is blue. He finds, and is supported in this by Lord Rayleigh, that the faintest light appears of a greyish-green colour; and Captain Abney attributes the apparent colour of moonlight to this cause. The author does not attach much importance to the application of this phenomenon as an explanation of the colour of the light of arcs, but it is worthy of record in this connection. When the eye passes gradually from daylight into electric light without seeing any distinctly yellow light, the sensation of blueness is rarely, if ever, observed.



FIGS. 13, 14, AND 15.

It would be easy to humour this optical illusion, as is done at the British Museum reading-room, by the use of screens of yellowish glass; but a much more important consideration is the value of the arc light for the proper discrimination of colours; and though it is found in dye works that most colours can be matched with a good 15 or 20 ampere arc, there appears to be no reason why a perfect reproduction of a standard daylight quality of whiteness should not be obtained—at all events, with arc lamps if not with glow lamps. The public would not be ready to believe it: they would call such a light bright blue, but that does not matter much. As the idea did not occur to the author until the autumn of last year, he has been unable to make experiments with summer daylight; but as it would be a misfortune if it were patented, he takes the present opportunity of describing the principle.

The full line in Fig. 13 is the luminosity curve for the light of the positive pole of an arc as determined by Captain Abney. The horizontal scale is the length of the spectrum, and the letters refer to the well-known line. The ordinates are a measure of the brightness of each part of the spectrum. The dotted line is the luminosity curve for sunlight in May, from the same authority. Fig. 14 shows the difference between these two curves. The portions which lie below the horizontal line represent the excess of orange and greenish rays in the arc, and the portion which lies above the line represents the deficiency in blue rays. Such a deficiency has the same effect on the eye as an excess of yellow, and the whole effect is distinctly more yellow than sunlight. The light of a glow lamp at ordinary incandescence is almost exactly the same as that of gas. Fig. 15 gives the luminosity curves of arc and gas; and Fig. 16 shows the difference which, when the curve of gaslight is reduced so as to fall wholly within the arc curve, as in Fig. 15, consists of a deficiency which increases rapidly towards the blue.



FIGS. 16, 17, AND 18.

Assuming ideal daylight to be rather less yellow—that is, more blue than sunlight—the dotted curves in Fig. 17 have been drawn from Captain Abney's curves of sunlight and the light of blue sky. One-third of the difference between sunlight and blue sky has been added to the sunlight. The dotted curves are of the same kind, but the ordinates have been reduced. Fig. 18 shows the differences. Compared with the strongest daylight curve, the arc has a marked excess of orange, and a deficiency of greenish blue. With weaker daylight there is a greater excess of yellow; and with the weakest light shown, since it lies almost entirely within the arc curve, there is practically no deficiency in the blue.

[*] American Institute of Electrical Engineers, May 21, 1890.

[†] Electrical Congress, Paris, 1889.

[‡] American Institute of Electrical Engineers, 1890.

[§] Société Internationale des Electriciens.

[‖] Dr. W. J. Russell and Captain Abney, on the other hand, say: "The light from a sky which is cloudy has very much the same composition as sunlight itself, as we have repeatedly proved." "The proportion of blue rays in sunlight near mid-day in May is very nearly the same as the standard light" ("the white-hot crater in the positive carbon pole of the electric light"). —"Report on the Action of Light on Water Colours," c. 5,453, 1888, pp. 23 and 69.

There are two different ways in which this result may be practically used to produce artificial daylight. A glass or other medium may be tinted with stains, or dyes, which will absorb the proper amount of yellow and red light, and the lamp may be surrounded by such a medium; or a reflecting screen may be painted with such a colour that this yellow light may be absorbed, and the white light alone may be reflected. Blue glass chimneys are used for microscope work, and are occasionally used for reading-lamps with the view of giving a more agreeable light. The lowest curve but one in Fig. 18 has a small deficiency of greenish blue. This would affect the eye as a very faint yellowish tinge. If the excess of yellow in the rest of the spectrum could be corrected, a very close approximation to daylight would be attained. About one-third of the useful power of the light would have to be sacrificed. With gas light or glow lamps more than two-thirds of the light would have to be absorbed in order to reproduce the effect of daylight.

Quite apart from considerations of colour-matching, the use of a white light ought to be good for the eyes, since all the nervous elements would be equally excited as in normal daylight. The author has not yet completed his experiments on coloured shades, but has produced colour screens, which, when illuminated by lamplight, reflect a light which cannot be distinguished from white when compared with daylight. It does not follow that the light is identical with daylight; but he hopes to follow up the matter during the summer.

LONDON COUNTY COUNCIL.

The following report of the Parliamentary Committee was presented and adopted at the meeting of the Council on Tuesday, with the omission of the suggestion that only one line should be constructed between North and South London:

ELECTRIC AND CABLE RAILWAYS.

A Joint Committee of Lords and Commons having been appointed to consider the best method of dealing with electric and cable railway schemes, we have considered the question of the evidence to be adduced on the part of the Council before the committee. We have had before us, in connection with the subject, reports by the parliamentary agent and the chief engineer, and have directed our attention to the third report of the Select Committee of the House of Lords, 1863, and the report of the Joint Committee of the Houses of Lords and Commons, 1864, on metropolitan railway communication. In our report to the Council on the 9th of February last, especial reference is made to underground communication, and suggestions are contained in that report which we have adopted, and decided to include in our proposals as to the line of evidence to be taken before the Joint Committee. Having given the whole subject our most careful consideration, we propose to submit to the Joint Committee the following propositions as indicating the position which the Council will take in the coming enquiry: (1) That the size of the tunnels of the lines should be sufficient to allow in the future of an interchange of traffic with existing railway lines. (2) That, subject to the other conditions and to any geological or other unforeseen difficulties which may be met with, underground lines should not follow the line of existing streets, but should go from point to point, the depth below the surface being such as to avoid injury or inconvenience to buildings in the line of the railways. (3) That the companies should only be allowed to acquire the right of forming the tunnels without acquiring any absolute freehold in the soil, paying compensation for actual damage only.

We are of opinion that the traffic capable of being accommodated by a railway of the class proposed between the North and South of London is not of so large an extent as to justify more than one railway. It would be at present impossible to obtain the necessary capital for the construction of more than one, as it would be obvious that if the traffic were divided between two lines, the expenditure on each must be unremunerative. We therefore think that the formation of more than one such line should not be encouraged.

In the Central London Railway Act, 1891, valuable provisions were inserted at the instance of the Council, which we think should also form part of any new Acts authorising further underground communication. We have given the agent the necessary instructions to take steps for submitting the views above set out to the consideration of the Joint Committee.

Another point to which we have directed our attention is the question of the desirability of urging on the Joint Committee the introduction in the Bills of clauses giving to the Council compulsory powers of purchase of the undertakings. There is a precedent for this in the case of the tramways, and we are strongly of opinion that in the public interest it is desirable that such a power should be reserved to the Council. Such undertakings are, in fact, in the nature of underground tramways; they are purely metropolitan, and are not railways in the sense of carrying passengers outside the metropolis. It appears, therefore, to us that the same principle may be adopted with them as with regard to tramways, with the addition of a concession that in a matter which requires a longer time to develop than mere horse traction on the surface of the street would require, there should be a period allowed, not of 21 years as in the case of tramways, but of 60 years, so as to enable those who find the capital in the first instance time to obtain remuneration for that capital.

We have accordingly framed for the consideration of the Joint Committee a clause on the model of section 43 of the Tramways Act, 1870, with the exception that a period of 60 has been substituted for 21 years. We propose that if the Council by resolution passed at a special meeting so decide, it may within six months after the expiration of a period of 60 years from the passing of an Act authorising such a scheme, and within six months after the expiration of every subsequent period of seven years by notice in writing require the company to sell, and thereupon the company shall sell to the Council the undertaking, the terms of payment being the then value (exclusive of any allowance for past or future profits of the undertaking or any compensation for compulsory sale or other consideration whatsoever) of the railway, and all lands, buildings, works, materials, and plant of the company, suitable to and used for the purposes of their undertaking, such value to be in case of difference determined by an engineer or other fit person nominated as referee by the Board of Trade on the application of either party, and the expenses of the reference to be borne and paid as the referee may direct. And when any such sale has been made, all the rights, powers, and authorities of the company in respect to the undertaking sold shall be transferred to and vested in and may be exercised by the Council in like manner as if such railway had been constructed by the Council under parliamentary powers. We recommend—

(a) That the course taken by us in instructing the agent to submit these views to the Joint Committee be approved.

(b) That the Council do approve of powers being sought to enable the Council eventually to acquire electric and cable railway undertakings, and do authorise the Parliamentary Committee to submit a clause on the lines indicated in the report, to the Joint Committee on the Bills.

TAUNTON.

The following is the report of Mr. G. Kapp relating to the installation at Taunton:

TO THE SANITARY AUTHORITY OF TAUNTON.

Gentlemen,—In conformity with the instructions received from your town clerk by letter dated April 8, 1892, I have now the honour to report as follows:

I visited the works of the Taunton Electric Lighting Company on the 13th and 14th inst., with the object of making a valuation which would guide you in arranging with the company the terms on which you would take over the whole undertakings as a going concern. Since any valuation of this kind must be made in such a manner as to conform with the requirements of the Local Government Board, I had, previously to my visit to Taunton, an interview with an official of the Local Government Board, and ascertained that in making the valuation it would be necessary to take into account not merely the market value of the different parts of the works, and the cost of erection, but also the probable life of the plant, and its general suitability for the supply of electrical energy.

The works comprise a central station, a complete system of overhead mains now supplying about 30 arc lamps for street lighting, and 40 arc lamps for private lighting, a number of glow lamps of various candle-power equivalent to about 500 16-c.p. lamps, and also three sets of storage batteries. The central station stands on a piece of land, 14,570 square feet in area 180ft. deep, and running through from St. James's-street to Middle-street. The buildings cover an area of 8,070 square feet, and enclose a total volume of 180,000 cubic feet. They comprise a boiler-room, 38ft. wide by 70ft. average length, an engine-room, 50ft. wide by 70ft. average length, small store-rooms, and lavatory. The chimney is circular and 120ft. high by 4ft. internal diameter at top. The buildings and chimney are large enough to accommodate boilers and electric light machinery for 500 i.h.p. or 600 i.h.p., and as the total requirements of Taunton for electric lighting will for years to come not exceed from 300 i.h.p. to 350 i.h.p., I consider the buildings and amount of land unnecessarily large. The great width of the engine-room is also objectionable, because it would make the addition of an overhead traveller (which is a necessary part of a properly-equipped station) a costly affair.

THE GENERATING PLANT COMPRISES THE FOLLOWING:

Two Babcock-Wilcox boilers, each of 1,000 square feet heating surface, and capable of evaporating from 3,000lb. to 3,500lb. of water per hour, the steam pressure being 140lb.

Two Worthington feed pumps, with steam and feed connections.

One exhaust steam feed heater.

Two large cast-iron water-tanks and one blow-off tank.

One oil filter.

Two Ruston-Proctor horizontal compound engines, with automatic expansion gear, cylinders 10in. and 17in. by 18in. stroke. These engines will indicate about 90 h.p. each.

Two Willans central valve engines, HH pattern, rated at 140 i.h.p., but working at present much below this power.

One countershaft, 5in. diameter and about 30ft. long, with five bearings on massive pedestals, two cast-iron main pulleys with claw clutches, by which the countershaft is belted to the Ruston-Proctor engines, and five wrought-iron pulleys with friction clutches, from which are driven by belts:

Four Thomson-Houston arc light machines, each intended for working 30 6·8 ampere arcs in series, and

One Elwell-Parker shunt-wound dynamo working the battery circuit above mentioned.

There are also in position and belted to the Willans engines:

Two Thomson-Houston alternators rated at 70-kilowatt machines (2,000 volts 35 amperes), each alternator driving by belt its own exciter.

The station contains the necessary switchboard and instruments for the alternators, controllers, and plugboard for the arc light machines, and a switchboard for the charging dynamo. The necessary instruments for testing the insulation of the machine and circuits are also provided.

The exhaust pipes are carried underground, but are only partly accessible.

The system of steam-piping is very defective, and hardly safe. There are no isolating valves on the boilers, and the main steam pipe is of cast iron, and no provisions have been made for expansion and contraction. There is a steam-separator fixed to the main steam-pipe, but it is placed in such a position that it cannot drain the whole of the main steam-pipe. Further, there is no ring main affording the steam an alternative path in case it should be necessary to affect any repairs whilst the station is under steam. Thus, the blowing of a joint in the evening would necessitate the shutting down of the station, to say nothing of the permanent danger of carrying 140lb. of steam in cast-iron piping.

The belts joining the Willans engines to the alternators should be properly fenced; in their present condition they are a source of danger to the attendants, who are in the habit of stepping over these belts whilst running.

It would also be advisable to place the alternators nearer to the Willans engines in order to reduce the length of belt centres. As at present arranged, the belts are unnecessarily long, and the strain causes the bearings of the alternators to heat. The exciters should be placed on the opposite side. The framework of the alternators should be connected to earth.

The Distributing Plant Comprises the Following:

About 120 posts fitted with oil insulators for the support of overhead mains. About 31 of these posts are also fitted with brackets, hoods, spring contacts, and hoisting gear for the street lamps, which are of the Thomson-Houston 6·8 ampere M 12 type. The posts, especially those at street corners, appear to be weak, and the automatic spring contact for the lamps is too flimsy and unreliable. The hoisting gear is also defective, the winch barrel and top pulleys being too small in diameter.

Most of the posts carry three distinct circuits—namely, one for the street lamps, one for the arc lamps fixed on consumers' premises, and one for the alternating current. Some of the posts also carry the battery current, making four distinct circuits in all. The arc lamps fixed on consumers' premises are Thomson-Houston 6·8 ampere lamps of the D 12 type, and are worked in series of 21 and 22 lamps respectively. The system of working, under which the high-pressure circuit is looped into private premises, is not so safe as the more modern plan of working private arc lamps from low-pressure mains. I shall have occasion to refer to this subject again in a later part of this report.

The glow lamps are worked by transformers, which are fixed on the consumers' premises, and care has been taken to place the transformers into such positions as to be not easily accessible. Although in this way the danger of admitting a 2,000-volt current into private premises has been greatly minimised, yet it is not altogether absent, and it would have been much better to have placed the transformers at sub-stations, so that, as recommended by the Board of Trade, only the low-pressure current is admitted into private premises.

Condition of Works.

Apart from the various defects pointed out above, and which refer rather to the design of the works than their state of preservation, the whole of the plant is in good, and some even in excellent condition. The boilers and accessories are perfectly serviceable, as are also the Ruston-Proctor engines. The Willans engines are in fairly good condition, but should be overhauled, and brackets should be fixed to support the spindles of the steam stop-valves. There seems also to be a slight crack in the steam-pipe to one of these engines. The countershaft and all the belts are in good condition, and the alternators, with their exciters, as well as the arc light dynamos, are in excellent condition. The insulation of these machines, and of all the overhead mains with arc lamps and transformers in circuit, I found remarkably good, notwithstanding the fact that my tests were made on a rainy day. The whole of the plant has been well cared for.

Methods of Working, Efficiency, and Consumption.

The supply of electrical energy from the station is at present intermittent, the machinery being started in the afternoon and kept going till 1 or 2 o'clock in the morning only. Although such a manner of working is, generally speaking, conducive to economy, it has not been so in the present case. I have been able, by the courtesy of the directors of the company, and with the assistance of Mr. H. E. Hunt, the superintendent, to estimate approximately the number of units supplied for private and public lighting, and the amount of coal consumed, and I find that for the delivery of 80,000 units during the year 1891, 870 tons of coal were burned, being at the rate of about 24lb. of coal per unit delivered. Had the company been working under a provisional order and been compelled to keep the pressure on the mains for private lamps continuously, the consumption of coal per unit supplied would have been still greater. Under the favourable conditions of intermittent supply the consumption of 24lb. per unit delivered is far too large. Modern and well-designed stations giving uninterrupted direct-current supply at low pressure, require from 9lb. to 15lb. of coal per unit; and alternating-current stations giving uninterrupted supply, require from 12lb. to 24lb. of coal per unit. There are chiefly two reasons why the coal consumption in the Taunton station is so large. In the first place, the average load on the alternators is very small in comparison with the rated power of the engines, and, in the second place, the efficiency of the arc lighting plant is low, owing to the interposition of a heavy countershaft between the engines and dynamos. This defect cannot be remedied with the existing plant, but the efficiency of the alternating plant would be materially improved if, instead of 500 lamps, three or four times this number were connected, and the supply were still carried on intermittently as now. Should it, however, be necessary to give an uninterrupted supply, as is generally the case when the undertakers work under a provisional order, then it would only be possible to attain a fair efficiency by the addition to the present plant of a small engine and alternator for daylight work, and the establishment of sub-stations with large and small transformers.

Commercial Results, Meters, Possible Profit, etc.

That statement No. 1 contained in the report of your Joint Committee gives the total working expenses during 1891 at £1,897. 2s. 9d., and the income at £1,521. 1s. 3d. The different items of expenditure are, with the exception of those for coal, oil, and water, fair and reasonable. The coal bill would, in my opinion, not be reduced by the introduction of a mechanical stoker. The station has been worked in a manner as economical as the nature of the plant permitted, and I do not think that in future it will be possible to reduce expenses. The commercial results can therefore only be improved by increasing the receipts. The receipts were, in round numbers, about £1,110 from arc lighting and £410 from incandescent lighting, the latter being charged at an average of 1s. per candle-power per annum, whilst each private arc lamp figures in statement No. 2 at £10 per annum. The 41 private lamps consumed during 1891 about 17,000 units, and the income from them figures in the statement at £410, which is the payment for the rent of the lamp, the carbons consumed, and the current supplied. Deducting £80 for rent of lamps and carbons, we find that 17,000 units were supplied for £330, which is at the rate of 4·65d. per unit. Since the cost of producing a unit was during 1891 about 5·7d., it is clear that the private arc lighting was a loss to the company. If the current for these lamps had been charged by meter at 8d. per unit, there would have been a small profit on the private arc lighting, each lamp earning about £4 per annum. In so far, and provided the consumers will submit to the increased charge as determined by the meter, the adoption of meters would increase the income, but I do not think that the adoption of meters would increase the income derivable from the incandescent lamps. In London the average earning power of an 8-c.p. lamp, with current at 8d. per unit, is about 10s., and of a 16-c.p. lamp it is under 20s. There is no reason to anticipate a higher revenue per lamp in Taunton, where the influence of heavy fogs cannot be so favourable to the interests of an electric lighting company as is the case in London. It will, therefore, be hardly safe to reckon upon a higher income per 16-c.p. lamp than 18s. per annum. In order to fully utilise the present plant at the central station, a total of 1,400 or 1,500 lamps may be connected. The Ruston-Proctor engines should also be capable of supporting an additional load of, say, 13 arc lamps for street lighting. If the current for the private lamps be charged at 8d. per unit the total income would be as follows:

From 44 public arc lamps at £22. 10s.	£990
From 41 private arc lamps	560
From 1,500 16-c.p. incandescent lamps	1,350
	£2,900

It would of course be necessary to put down one additional boiler and additional transformers. It would also be necessary to make the improvements in the steam-piping, valves, etc., detailed above, and to place the whole of the street mains underground. The cost of these additions, alterations, and improvements would amount to about £3,500. The working expenses would be increased as compared with those incurred during 1891 by the following amounts:

For coal, water, oil and petty stores	£400
For repairs and renewals	70
For salaries and wages	80
	£550

This would bring up the total working expenses to £2,450, leaving a gross profit of £450.

I must here point out that this profit will only be obtainable if the station is worked as at present—that is to say, giving an intermittent supply. If the supply had to be uninterrupted, the machinery at the station would have to be kept in motion night and day. This would very materially increase the cost of coal, water, oil, repairs, and renewals, and, above all, the wages; since, instead of one shift of men, as at present, three shifts would be required. I need hardly say that under these circumstances the above-mentioned profit of £450 would be converted into a heavy loss.

System of Supply.

The system of supply for which the Taunton central station has been designed is not well suited to the local conditions. Where a district extending over several miles has to be supplied with electrical energy, the use of high-pressure alternating currents and transformers is perfectly justified, and the working (owing to the necessarily large number of lamps installed) is economical. But in a small district there is no need to use high-pressure alternating

currents, and it is, moreover, uneconomical in working, because the number of lamps must necessarily be small, and the cost of keeping machinery continuously in motion must be large in comparison with the possible revenue. In Taunton, the central station lies within a comparatively small district, and the whole of the lighting is at present comprised within a radius of about 800 yards from the central station. As distances up to 1,200 yards are well within the reach of the ordinary three-wire system with uninterrupted direct-current supply, and as the whole profitable lighting area of the town lies well within this limit, there is no need for the alternating-current system. Taunton could very efficiently be lighted on the direct current system, the generating plant including storage batteries, so that an uninterrupted service can be given without the necessity of working the machinery for more than 10 hours daily.

Board of Trade Requirements.

If you were to take over the existing electric light station, you would have to work it in conformity with such rules and regulations as the Board of Trade may insert in the order with a view to ensuring the public safety and convenience. There are certain conditions peculiar to the system of lighting adopted at Taunton, which would have to be specially approved of by the Board of Trade, and as it is necessary to know beforehand whether such approval can be obtained, I had an interview with Sir Thomas Bloomfield, of the Board of Trade, and discussed with him the points stated below. The definite decision of the Board of Trade will be communicated to me after the return of their scientific adviser early in May, but as this report must reach you before, I shall now merely state the points concerned and my own personal views.

Overhead Wires.—As all these are in urban streets they will all have to be replaced by new underground wires.

Uninterrupted Supply. – The model order provides that the undertaker shall "give and continue to give a supply of energy," etc. It is not quite clear whether this should be interpreted as meaning that the supply shall be uninterrupted, or merely given day after day during stated hours. Hitherto, the question has not arisen, it being tacitly assumed that supply companies give uninterrupted or continuous supply. Even in the case that the other interpretations were legally tenable, I do not think you could take advantage of it, as it would restrict the use of the light to certain hours, and thus make the electric light less convenient than gas. You would therefore be compelled to give an uninterrupted supply, and, as I have explained above, such a supply, if obtained by the use of the present plant, would entail a heavy loss in working expenses.

Arc Lamps in Shops. I have already referred to the possible danger of looping high-pressure mains into private premises for working arc lamps in series, and although the practice is not uncommon, and has, in England at least, not led to any accident as far as I know, yet the Board of Trade are at the present time considering the advisability of framing regulations with a view to public safety, or of forbidding the use of such a system of lighting altogether. In taking over the Taunton electric lighting station you would, of course, also take over the risk of having to rearrange, or completely remove, these private arc lamps, replacing them by low-pressure arcs, should the decision of the Board of Trade be unfavourable to them.

Purchase.

Part of the instructions given me by your town clerk was that I should make a valuation of the works of the Taunton Electric Lighting Company, in order to advise you what would be a fair and proper price to pay, in case you should decide to take over the whole undertaking. The price suggested for the purchase in the report of your Joint Committee is £10,000, and if the design of the station had been such as to fully meet the conditions indispensable for economical and efficient working, as well as the requirements of the Board of Trade, I should consider this price a fair and reasonable one to pay for the land, buildings, machinery, and building plant. Unfortunately, however, the design of the station, and the whole system under which the light is at present supplied, is not such as will allow of economical working, if the supply is to be continuous, such as the consumers would have a right to demand, and therefore I cannot advise you to buy up the works as a going concern, or in any such manner as would compel you to carry on the present system of supply.

The main reasons on which my advice is based have been given at length in the foregoing paragraphs of this report, and I need, therefore, not repeat them here. There is, however, a further reason to which I have to draw your attention—namely, the two agreements existing between the company and Messrs. Laing, Wharton, and Down, dated respectively the 19th March, 1886, and the 13th December, 1886. I have carefully studied these agreements, and I find that the clauses therein contained, and especially clauses 4, 5, 6, and 7 of the first agreement, would seriously restrict your freedom of action, and practically prevent you from introducing any improved machinery and methods of supply in the future, except by permission or with the assistance of Messrs. Laing, Wharton, and Down. Whatever arrangement you may come to with the Taunton Electric Lighting Company, I advise that you do not take over these agreements, but retain full liberty as regards the system and method of working and the purchase of plant in the open market.

Improved Electric Light Supply.

If you determine to become undertakers for the supply of electrical energy, this may be done in either of two ways.

(a) You may erect and work an entirely independent central station. The advantage of this course would be that the station could be designed and built on the most improved modern principles, and on a site at the river bank, so that condensing engines can be employed, and the coal delivered by barge. There would be the further advantage that the present system of supply would not be in any way interfered with, so that there would be no inconvenience whatever to consumers, if eventually they should have to change from the old to the new system of supply. There would, however, be this very serious objection, that you would enter into competition against the existing company, and on that account the following way is preferable:

(b) Although not buying out the existing company as a going concern, you may buy so much of the plant belonging to the company as can profitably be employed in the reconstruction of an improved central station and distributing system, leaving the company free to sell the rest of its plant in the open market. The advantages of this plan, are that it will not take so long as plan (a) to get the improved station into working order, and that it will be financially better for the company. The disadvantages are that your station will not be on the river, that its internal arrangement will not be quite as perfect as would be the case if the whole of the works were designed afresh, and that there might be some slight and partial interruption of light when changing over from the old to the new system.

I take it that the plan (a) does not come within the instructions given me by your town clerk, and shall therefore confine myself in the following to plan (b), under which you would purchase as much of the old plant as can be profitably employed in the improved station, paying for this plant a fair and reasonable price. In determining what this price should be I have adopted the following method. I have assumed that the total requirements of Taunton for electric lighting during the next four or five years will not exceed 44 street arc lamps, and 2,000 16-c.p. glow lamps, or their equivalent in arc lamps, and glow lamps of other candle-power for indoor lighting. I have further assumed that eventually the total amount of lighting may be extended by 50 per cent., and I have estimated the cost of a new central station and distributing plant, the chimney and buildings being provided for 3,000 16-c.p. glow lamps installed, and 66 arc lamps in the streets, whilst the machinery provided at present shall only suffice for 2,000 glow and 44 arc lamps. I find that the cost of such an electric lighting works (including 7,000 square feet of land which I value at £400) will be from £15,000 to £16,000, made up as follows:

Land, chimney, buildings, traveller, boilers, machinery, batteries, and all accessory apparatus at central station...	£8,200
44 street arc lamps with posts and circuits	2,000
Underground mains, house connections, and meters	5,300
	£15,500

I have also estimated the cost of altering the present station, and adding certain machinery and apparatus, by which means the present station can be made very nearly as efficient as the entirely new station costing £8,200. The difference between these two estimates is the price which you can afford to pay to the company for those parts of the station which you can utilise, and which are: Land, chimney, and buildings; boilers and accessories; two Ruston-Proctor engines and two belts; one Willans engine; the system of exhaust pipes; small accessories, such as benches, vices, clock; barrow, wiring of stations, etc.

If you utilise this material the cost of additional machinery will be £3,700. You can therefore afford to pay the company the difference between £8,200 and £3,700, or £4,500 for the above-mentioned material. You will notice that I have only included one of the Willans engines, since this and the two Ruston-Proctor engines would correspond with the three 100 i.h.p. engines that would have to be put down if you were to build an entirely new station. As, however, the second Willans engine would be required for future extensions, and as its possession now would tend to minimise and possibly entirely avoid the interruption of lighting during alterations, I advise that you take it over also, and on this account the above-mentioned purchase price would have to be increased by £400, making the total price for the central station £4,900. This refers, of course, only to the boilers, engines, and accessory plant at the station, but it does not refer to the dynamos, mains, lamps, and transformers, all of which would be useless to you. As regards the posts, you could utilise 44 of them for lampposts at the price of £350, leaving the company to remove the other 76 posts and dispose of them along with the wires, dynamos, and electrical plant in any way they may think fit. The total price you would under the suggested arrangement have to pay to the company would therefore be £5,250, made up as follows:

Land, chimney, buildings	£2,500
Boilers, water-tanks, feed-pumps, feed-pipes, exhaust heater, exhaust pipes	800
Two Ruston Proctor engines and two belts for same	550
Two Willans engines	800
44 lampposts	350
Stores for engines and boilers, accessories, and fixtures......	250
	£5,250

The material which you would have to purchase in the open market in order to complete the equipment of the station would comprise: One dynamo adapted for direct driving, and fitted to one of the Willans engines; two dynamos adapted for belt driving from the Ruston-Proctor engines; one boiler of the same size and type as the present boilers; storage batteries, switchboard, regulating appliances, adapted for low-pressure direct-current supply on the three-wire system, giving an uninterrupted service day and night.

My estimate for this plant, including erection and setting to work, is:

Boiler	£330
Steam-pipes for three boilers and four engines	230
Dynamos	1,400
Batteries, switchboards, and regulating appliances	1,100
Structural alteration to building and traveller	180
Contingencies	460
	£3,700

The street mains should be treble concentric cables, lead-covered and compounded, and would be laid in about 3,800 yards of street, partly on both sides, so that the total length of frontage served would be 5,300 yards. This is in excess of the frontage served at present. The current would be supplied to the mains by feeders at 210 volts, and to consumers' terminals at 105 volts, the pressure being kept on continuously night and day, so that consumers may use the energy during the day for motive or other purposes. My estimate for the feeders and mains, including opening and making good of streets, junctions, testing and connecting boxes, house services and meters, is £5,300. The arc lamps would be worked from the junction-boxes in series of four across the 210-volt mains; and each group of four arc lamps would be turned on and off by a switch in one of the lampposts. My estimate for the arc lamp installation, including posts, lamps, switches, hoisting gear, and underground mains is £2,000, of which sum the £350 paid to the company forms the item for the cost of lampposts.

Your total outlay for the electric lighting plant for 44 street arc lamps and 2,000 16-c.p. glow lamps installed, or equivalent arc lamps and glow lamps of other candle-power (of which not more more than 1,400 will ever be required to burn at the same time), is, therefore, as follows:

Price to be paid to present company for central station and material as detailed above	£5,250
Cost of additional plant at central station	3,700
Feeders, mains, house connections, and meters	5,300
44 arc lamps and mains	1,650
Total	£15,900

WORKING EXPENSES AND REVENUE.

The annual working expenses of the station will be as follows:

Coal and firewood, 536 tons at 16s.		£450
Water, 900,000 gallons at 1s.		45
Oil, waste, and petty stores		75
Carbons for street lamps		100
Repairs and renewals to buildings	£40	
,, steam and dynamo plant	200	
,, batteries	100	
,, street mains	100	
,, arc lamps	20	
		460
Salaries and wages:		
One superintendent and one clerk	£330	
One stoker, one driver, one battery man, one lamp trimmer	250	
		580
Office and sundry expenses		70
		£1,780

As shown above, £15,900 will be required for the works, to this should be added about £1,000 for working capital, so that the total sum you would have to borrow amounts to £17,000. This must be repaid in 30 years, the annual payment being in round numbers £880, which, added to the £1,780 working expenses, brings up the total annual outlay to £2,660.

The revenue to be derived from the working of the station may be estimated as follows:

44 street lamps at £22. 10s.	£990
2,000 16-c.p. glow lamps at 18s. per lamp, or their equivalent at 8d. per unit	1,800
Rent of meters	50
Sale of current for motive power	60
Total revenue	£2,900

There would thus be a small profit—namely, £240—on the working of the station, and this would be increased with the use of current for motive power and with the increased use of the light up to the ultimate capacity of the station. The street mains which I have included in my estimate would enable you to bring current to the railway station, where both glow and arc lamps could be installed, and, generally speaking, you would be able to supply current to a distance not exceeding 1,000 yards from the central station. If you should desire to supply current to the Wesleyan College, it could be done by a separate high-pressure alternating-current supply with overhead mains starting from some point near the Shire Hall. The Board of Trade will raise no objection to overhead mains outside the town. A small alternator, combined with a direct-current motor, would be required for this service, the motive power being derived from the low-pressure supply. The supply of light to the college could, however, only profitable if it were restricted to the hours between dusk and 1 or 2 a.m., and the lighting carried on under a special contract independent of the provisional order.

GENERAL CONCLUSIONS.

I have, in the foregoing, dealt in detail with the various questions arising in connection with your taking the electric lighting of Taunton into your own hands; and for your convenience I now give a short summary of the results of my investigation.

1. The present electric lighting system is not suitable for small areas, and cannot be worked at a profit if the supply must be continuous. For this reason I cannot advise you to buy the undertaking as a going concern.

2. Taunton can be lighted most economically on the direct-current low-pressure three-wire system, with batteries to take the day load.

3. If you determine to start an entirely new station, it should be placed close to the river.

4. If you determine to utilise the existing station, you can take over the buildings, boilers, engines, and accessories, and 44 iron posts, paying the company £5,250.

5. The existing countershafting, dynamos, alternators, transformers, batteries, overhead mains, and arc lamps not to be taken over, but to be removed by the company.

6. The total cost of a complete works suitable for the supply of 2,000 16-c.p. private glow lamps, and 44 street arc lamps, is £15,900. The annual working expenses will amount to £2,660, including repayment of loan, and the annual revenue will amount to £2,900.—I am, gentlemen, yours faithfully,

(Signed) GISBERT KAPP, M.Inst.C.E.

Westminster, April 26, 1892.

COMPANIES' MEETINGS.

METROPOLITAN ELECTRIC SUPPLY COMPANY.

The shareholders of the Metropolitan Electric Supply Company, Limited, held their fifth ordinary general meeting on Friday last at Winchester House, Old Broad-street, E.C., Sir John Pender, K.C.M.G. (the chairman), presiding.

The **Secretary** (Mr. E. Cunliffe-Owen, C.M.G.) having read the notice convening the meeting,

The **Chairman** said: Gentlemen, the resolution which I have to put is: "That the report and accounts for the year ending December 31, 1891, presented to this meeting be, and the same are hereby, approved and adopted." Before I ask you to approve of that resolution I must give you a *résumé* of the year's work; but I beg that you will be rather indulgent to-day, as my voice is not quite up to the usual mark, because I am only just recovering from an attack of bronchitis. When I had the pleasure of addressing you 12 months ago I was able to report that our installations were all but completed, that our mains extended for 67 miles, that we had 480 customers upon our books, and that, looking at the rate which we had calculated as being the proper rate that we might possibly earn, we saw the prospect of a good profit. Our position to-day is strengthened because we have upwards of 1,000 customers upon our books, as against less than 500. Yet these customers are learning how to economise, and their consumption has not been in proportion to their increased number; but we have the satisfaction of learning from experience, and, after all, our knowledge of electric lighting is based upon the experience we gather from day to day. But taking the consumption from our meters, the probability is that we shall be able to supply double, or even more than double, the number of lights we originally contemplated; so that all the expenses in connection with the production of the light have been, I may say, already incurred; and what we want now is more customers rather than a larger rate of consumption from our present number. At all events, we are not depending upon that, but upon additional customers, because I would rather see our return based upon 5,000 customers than upon 2,000 customers, so that what we want now is to exercise patience and push our business. We are a paying concern. It is growing every day, and while we are passing through very much the same phase of troubles that the gas and telegraph companies passed through, which latter companies have been passing under my own eye, I can see that there is a very satisfactory future before us, a satisfactory future to those who stand by the Company, and that there will also be a growing dividend. We did not contemplate Paddington in our first outlay, and therefore we have exceeded our capital expenditure by about £50,000. But in this case we have brought a very important district into our system—one which is likely to prove valuable in future; but concerns like this must grow, and when we have secured for it an amount of custom to take up all the light that we can produce, it will then turn out a very important installation indeed for the Company. I think it will be right to give you at the present moment an idea of the position of our Company as compared with other companies. On January 1, 1892, the London Electric Company had 36,000 lights, Westminster 62,000, Kensington and Knightsbridge 38,000, Pall Mall and St. James's 38,000, Chelsea 28,000, House-to-House 19,000, Notting Hill 3,000, and this Company 82,000, and we have since increased to 97,000. I find that in the last three weeks we have obtained applications for 5,137 lamps. This is the largest number ever obtained in the same time. You see, gentlemen, we have got everything ready to supply the public. In fact, we have the public almost clamouring to get on to our list, and it is therefore a question with us of patience, and if we stand by this growing concern, depend upon it the same harvest will be reaped as has been reaped by gas companies and telegraph companies. There has been, unfortunately for electric lighting, a great deal of speculation, but we have not been in that speculation. We have built up this concern not on a speculative basis at all, but we have built it up on the lines that the several installations should be independent of each other. We are, I believe, the most complete, economical, and handy system of electric

lighting that exists in the city of London at the present time. Any speculation we have had has not been in money, nor as far as the lighting is concerned, but speculation as to the best and cheapest mode of producing the light. I have much sympathy with those who have spent a great deal of money, and, I am afraid, not to any good purpose, having put too many eggs in one basket. That has not been our principle—quite the reverse ; but it would have been a very grand step in electrical science if we had been able to recognise that these great speculative ventures had ended in a great success. I fear financially, for the moment, it has not been so, but while it has reflected more or less upon electric lighting disadvantageously, we are on a sounder and stronger foundation, because we have proved our position, and are, as I say, now a paying concern. I suspect that for the moment disappointment has, more or less, affected the general body of the electric lighting companies' shareholders ; but I may say that it has not shaken my belief in the future of the electric light. And as London and its suburban population is about the least well supplied of any of the large cities in Europe, I consider that the field is only beginning to be occupied, that it is a very wide field, and when it is occupied it will be a very remunerative field indeed to those who have the courage to watch its progress with patience and stand by it. I shall not trouble you by going into the accounts. Our accounts are made up in accordance with the requirements of the Board of Trade. You have them before you. They speak for themselves, and they have been superintended and approved by your auditors, but if any gentleman wishes to put any questions to me on the subject, I shall be very pleased to answer him. As I have already said, we shall want a certain amount of additional capital, and we propose to raise that capital, as it will be only temporary, by the issue of £100,000 of debentures. I do not think we shall need to use more than £50,000 of this amount, but we think it better to be prepared for raising the extra amount should we require it. I am glad to take this opportunity of informing you on the subject. We shall issue these debentures *pro rata* to the shareholders at par, and to meet the smallest investors. We think we offer a plum to every investor in this Company, and, while we give this rate—which I consider rather a high rate under ordinary circumstances—still, the amount is small. We wish to show the shareholders that we are in touch and in sympathy with them, and we wish to encourage them to go on by giving them a little better debenture than they could procure elsewhere. They cannot procure a better debenture anywhere than those we offer them. We may pay them off within five years, but we intend to pay them off in 5½ years. I have stated before that when we get our present system in working order it will be only the beginning of what, I believe, will be a very extended system indeed. But we are not going to run any risks ; we intend to satisfy ourselves, and thoroughly nurse what we have got, and which is good, nursing it up to a point which will enable us and you to say "Go ahead !" In that case we may require more money, and will require to deal with the £100,000 of debentures in a more extended order ; but in the meantime we do not expect to spend more than £50,000, so as to enable us to complete our Paddington system. Then we shall rest, and watch the progress of it, and when I meet you another year I hope I shall be able to show you that, as we have doubled the number of our customers since we last met, so we shall have doubled the present number when I meet you again. With these remarks, gentlemen, I beg to move the resolution which I have read.

Mr. J. Denison Pender (deputy-chairman) seconded the motion, which was unanimously adopted.

The **Chairman** next proposed : "That a final dividend of 2s. per share on the whole of the ordinary shares of the Company be, and the same is hereby, declared, such dividend to be payable on May 14, 1892, to all holders on the Company's register on April 30, 1892."

Admiral Sir George H. Richards, K.C.B., F.R.S., seconded the motion, which was agreed to.

On the motion of the **Chairman**, seconded by **Sir James Anderson**, Mr. J. Denison Pender, Admiral Sir George H. Richards, K.C.B., and Mr. John Benjamin Verity were re-elected directors of the Company.

Mr. Mullett moved the reappointment of Messrs. Deloitte, Dever, Griffiths, and Co. as auditors of the Company.

The motion having been seconded,

Sir T. Baxley enquired whether any sum had been written off for depreciation of accumulators.

The **Chairman** : We have no accumulators.

Sir T. Baxley : Have you written anything off for depreciation of the machinery ? It is quite evident that the machinery upon which £129,000 was expended up to December 31, 1890, is not worth that amount now.

The **Chairman** said that the responsibility of the accounts rested with the auditors, and perhaps Mr. Griffiths would answer the question. The principle of writing off for depreciation was a sound one, and should be observed. He might, however, tell them that the Board of Trade had passed the accounts.

Mr. Griffiths (the auditor) : In reply to the observations of the shareholders, no reserve has been made for depreciation of accumulators, machinery, or plant this year. I think the shareholders will see that as the Company is practically in its infancy, and has not yet by any means reached its full power of working, it would be hardly fair to charge any depreciation in so small a revenue account. All expenses of repairs and renewals, however, are charged against revenue.

The **Chairman** : The moment the capital account is closed, and we are beginning to make money, we shall write something off for depreciation.

Sir T. Baxley thought that something ought to have been written off for depreciation, and therefore he maintained that the profit was not earned.

The **Chairman** : That is a matter of opinion. The time has not come yet to write off the depreciation ; but when it does come it shall be written off.

A Shareholder : What is the utmost capacity of your machinery in the way of lights ?

The **Chairman** : I believe the capacity is now about 250,000 lamps. There was a general impression last year that the amount charged for electric lighting was too small ; but now the idea is to supply a much larger number of lamps at a smaller rate. I think our average price is more likely to be 10s. than 20s. per lamp. I certainly think we shall build up our business on a better foundation by obtaining a large number of customers at a small rate than by having a few customers at a high rate.

A Shareholder : Do we undertake contracts for the wiring of houses ?

The **Chairman** : We feel that, as there are so many people engaged in installation work, if we were to take it up, we should have that particular trade against us, and that is not desirable. Besides, I believe it would require additional capital if we were to carry on that business ; therefore, I think it is better that we should allow that work to be done by others. There is a company which has lately been formed for doing that work, and I wish it Godspeed.

The motion for the re-election of the auditors was then put and carried.

Mr. W. T. Smith : Is our light likely to be used for street lighting ?

The **Chairman** : Negotiations are now going on for lighting Oxford-street.

On the motion of the **Rev. Walker Flower**, a vote of thanks was given to the Chairman and Board.

The **Chairman**, in acknowledgment, said : I must confess that I am a little disappointed to-day that I am not paying you a better dividend, because I thought by doubling the number of our customers we should double the amount of our trade.

The proceedings then terminated.

SUBMARINE CABLES TRUST.

The ordinary general meeting of the certificate-holders of this Trust was held on the 5th inst., at the offices, Winchester House

Sir John Pender presided, and, in moving the adoption of the report, stated that the expenses for the year had been £1,186, or £11 more, but the cost of administering the Trust was £813 under the amount provided by the trust deed, owing in a great measure to the trustees not having filled up the vacancies as they occurred by the death of their colleagues. They thought, however, that the time had now come when these vacancies should be filled, and they had considered it judicious to select two younger men, who, nevertheless, had considerable experience in submarine telegraph business and knowledge of the securities in which the capital of the Trust was invested. They had paid during the year £7. 2s. 6d., but the balance brought forward from last year was equal to 15s. 7d. per cent. on the value of the outstanding certificates. Their revenue during the past year had been sufficient to meet two coupons of £3 each, and pay off about an additional 7s. of the overdue coupon. There remained still a balance of £1. 17s. 6d. in arrear, but should the dividend on their holding in Anglo-American stock improve and the income from their other investments be maintained, they trusted that this arrear would be gradually paid off. They hoped to pay the balance of the coupons due on the 15th ult. on or about 1st of August.

Sir James Anderson seconded the resolution, which was carried unanimously.

On the motion of the **Chairman**, seconded by the **Marquis of Tweeddale**, a resolution was afterwards passed electing Mr. John Denison Pender and Mr. Kenneth Anderson trustees.

The **Chairman** stated that the Trust was of a peculiar nature, being practically a tontine, which would wind itself up in a certain number of years, and therefore they required youthful men to see the end of it. At the same time he thought that the young men who had been appointed trustees that day would have hereafter to elect others to succeed them.

COMPANIES' REPORTS.

CHELSEA ELECTRICITY SUPPLY COMPANY, LIMITED.

Directors : J. Irving Courtenay, Esq., chairman ; Major-General Webber, C.B. (retired R.E.), deputy chairman ; Nugent Daniell, Esq., Emile Garcke, Esq., Sir George Prescott, Bart. Secretary : S. J. Cluer.

Report of the Directors and accounts for the year ending December 31, 1891.

The number of lamps installed on December 31, 1890, was 19,580, and on December 31, 1891, 27,500 ; the number installed at the present time is over 30,000. The gross revenue for the year is £10,172. 10s. 11d., as against £6,079. 12s. 5d. for 1890 ; and the gross profit for the past year £1,750. 11s. 4d., as against £542. 19s. 5d. for 1890. There has also been a decided reduction in the cost of producing the electricity, but, as the new chimney and the rearrangement of the plant were not completed until

the end of the year, the improvement was obtained only in the last quarter of the year, as the following figures will show. The coal, water, wages, and other running expenses, for the first nine months of the year amounted to 4·5d. per unit sold, while for the last three months of the year they were only 3·0d. per unit, or 37½ per cent. of the revenue, and there is every reason to believe that the improvement will continue. The management expenses, including rent, rates, and taxes, now represent 1·9d. per unit sold, as against 3·0d. per unit for 1890. The plant is all in good working order, and the mains are in first-rate condition and have given no trouble. It has not been deemed advisable to make an issue of the preference capital authorised by the shareholders at their last meeting, but the remaining £10,000 first mortgage debentures (part of an issue of £30,000) have been allotted. The money thus raised has been applied to the purchase of a site for an additional storage station, to additions and improvements to generating plant, to enlargements and extensions of mains, and to the building of a second chimney stack. The Directors have to report the retirement from the post of managing director of Major-General Webber, C.B., who retains his seat on the Board as deputy chairman. The retiring Directors are Major-General Webber and Mr. Daniell, who, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Bros. and Co., also offer themselves for re-election.

Capital.

Total share capital paid up	£46,885
Total loan capital borrowed	25,500
	£72,385

Capital Account Year ending December 31.

Dr.	Expended to Dec. 31, 1890. £ s. d.	Expended to Dec. 31, 1891. £ s. d.	Total expenditure Dec. 31, 1891. £ s. d.
Land and freehold buildings*	—	548 2 7	548 2 7
Leasehold buildings	9,172 13 5	1,081 10 4	10,254 3 9
Generating machinery and tools	10,643 2 7	7,690 10 5	18,333 13 0
Accumulators, motor-transformers, and regulating apparatus	13,798 2 10	2,165 19 1	15,964 1 11
Mains	15,701 18 9	2,275 6 2	17,977 4 11
Meters	2,124 3 4	751 5 1	2,875 8 5
Electrical instruments	126 16 6	—	126 16 6
Office furniture	149 19 9	44 7 3	185 7 0
Cost of provisional orders and other preliminary and development expenses	7,054 19 2	1,096 5 9	8,151 4 11
Parliamentary expenses opposing other provisional orders	—	304 14 0	304 14 0
	£58,762 16 4	15,958 0 8	74,720 17 0

* Includes property purchased subject to mortgage of £800.

Cr.	£ s. d.
Ordinary shares of £5 each fully paid	46,385 0 0
Founders' shares of £1 each fully paid	500 0 0
Debentures paid up	25,500 0 0
	£72,385 0 0

Note.—The whole of the issue of £30,000 first mortgage debentures has now been subscribed.

Revenue Account Year ending Dec. 31, 1891.

Dr.	£ s. d.	£ s. d.
A.—To Generation of Electricity.		
Coal or other fuel, including expenses on the same	2,692 11 0	
Oil, water, cotton waste, and engine-room stores	866 4 0	
Wages of men	1,079 14 3	
Repairs, maintenance, and renewals: Buildings, £65. 16s. 6d.; engines and boilers, £282. 16s. 8d.; dynamos, £242. 11s. 8d.; instruments, tools, and sundries, £30. 6s. 4d.	621 11 2	
		5,260 0 5
B.—To Distribution of Electricity.		
Wages at out-stations, meter winding and readings, etc.	267 7 8	
Stores used at out-stations, etc.	30 15 6	
Repairs, maintenance, and renewals: Mains, £14. 15s. 6d.; accumulators and apparatus at distributing station, and motor transformers, £431. 13s. 5d.; meters on consumers' premises, £66. 2s. 5d.	512 11 4	
		810 14 6
C.—To Rent, Rates, and Taxes.		
Rents payable	286 4 0	
Rates and taxes	166 0 6	
		452 4 6
D.—To Management Expenses.		
Directors' remuneration	600 0 0	
Salaries of staff	774 17 10	
Salary or commission of collector	136 5 4	
Stationery and printing	54 10 6	
General establishment charges	211 6 10	
Auditors of Company	25 0 0	
		1,802 0 6
E.—To Law and Parliamentary Expenses.		
Law expenses		35 6 8
F.—To Special Charges.		
Insurance	56 13 0	
Wayleaves	5 0 0	
		61 13 0
Balance, being gross profit		1,750 11 4
		£10,172 10 11

Cr.	£ s. d.
Sale of current (less allowances made)	9,681 19 1
Rental of meters	299 11 8
Transfer fee	0 2 6
Rents receivable and sundry small accounts	190 17 8
	£10,172 10 11

Net Revenue Account.

Dr.	£ s. d.
Interest on debentures paid and accrued to date	1,205 19 3
Fees to trustees for debenture-holders	100 0 0
Interest on mortgage of freehold (purchase subject to mortgage)	18 0 0
Balance of suspense account written off	297 9 0
Bad debts written off	64 6 8
Balance to be carried forward to next account	132 0 0
	£1,817 14 11

Cr.	£ s. d.
Balance from last account	67 3 7
Balance from revenue account	1,750 11 4
	£1,817 14 11

General Balance-sheet, Dec. 31, 1891.

Dr.	£ s. d.
Amount received as per capital account	72,385 0 0
Bills payable	3,094 12 4
Sundry creditors	5,433 16 11
Net revenue account: balance at credit thereof	132 0 0
	£81,045 9 3

Cr.	£ s. d.	£ s. d.
Amount expended as per capital account		74,720 17 0
Stores on hand—		
Coal	20 14 0	
Oil	18 13 5	
General stores, including work in progress	703 4 8	
		742 12 1
Sundry debtors for current supplied, etc., less bad debts deducted		4,062 2 6
Cash at bankers:		
The London and South-Western Bank	1,474 10 6	
Parr's Banking Company	6 1 8	
Cash in hand	39 5 6	
		1,519 17 8
		£81,045 9 3

NEW COMPANIES REGISTERED.

Engineering Exchange, Limited.—This Company has been formed, with a capital of £10,000, to provide, regulate, and maintain a building, room or rooms, suitable for an engineering exchange in London, and to acquire, preserve, and disseminate useful information connected with the engineering interests throughout all markets. The subscribers are: Messrs. R. Bolton, 110, Leadenhall-street, London; A. T. Salisbury-Jones, 33, Old Broad-street, London; W. P. Gallwey, 82, Chelverton-road, Putney; J. J. Dale, 123, The Grove, Hammersmith; F. B. Nicholson, 9, St. Petersburg-place, Bayswater; C. W. Potter, Swafford-road, Twickenham, and W. J. P. Moore, 104B, Mount-street, Grosvenor-square, London.

Sheffield Electric Light and Power Company, Limited.—This Company has been registered with a capital of £98,000, in £7 shares, to acquire and take over as a going concern the electrical lighting and electrical fitting business of the Sheffield Telephone Exchange and Electric Light Company, Limited, to enter into an agreement with that company, and to carry on the business of electricians, mechanical engineers, suppliers of electricity, etc. The first subscribers are:

	Shares.
J. Tasker, Crookes, Sheffield, manufacturer	1
J. Gamble, Endcliffe-crescent, Sheffield, manufacturer	1
G. Senior, Western-bank, Sheffield, manufacturer	1
G. Franklin, Claremont, Sheffield, accountant	1
W. Tasker, 1, Parker's-road, Sheffield, manufacturer	1
F. Tasker, 35, Aldred-road, Walkley, Sheffield, engineer	1
J. H. R. Tasker, Sheffield, engineer	1

The number of Directors is not to be less than three, nor more than seven; the first being the first five signatories. Qualification, £150; remuneration to be fixed by the Company in general meeting. Solicitors, Messrs. Broomhead and Co., George-street, Sheffield.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended May 6 were £2,710.

Eastern Extension Telegraph. — The receipts for April amounted to £38,824, as against £44,729 in the corresponding period, showing a decrease of £5,905.

City and South London Railway.—The receipts for the week ending May 8 were £802, against £695 for the same period of last year, or an increase of £107. The total receipts to date from January 1, 1892, show an increase of £1,278, as compared with last year.

Consolidated Telephone Construction and Maintenance Company, Limited.—The Directors recommend dividends at the rate of 6 per cent. on preference shares, and 1 per cent. on the ordinary shares, less income tax, for the half-year ending March 31 last, making, with the interim dividends paid, 6 per cent. per annum on the preference, and £3. 10s. per cent. on the ordinary shares for the year.

Metropolitan Electric.—Sir T. Bazley, in his contention about depreciation at this Company's meeting, showed that he was not only a sensible but also a business man. The answer he got was, however, just what might be expected from the men who are running this concern, and what we foresaw would be made There was no depreciation made, because more money was wanted. This is not business; it may be finance or *finesse*.

Swan United Electric Light Company, Limited.—The Directors of this Company have resolved to pay an ad interim dividend at the rate of 8 per cent. per annum, free of income tax, for the half-year ending 31st March, 1892, to be distributed in accordance with the articles of association. The dividend will be paid upon the register as on May 10, and the dividend warrants will be issued on the 31st May instant. This works out at 2s 9d. and two-thirds of a penny per share on the ordinary shares, and 3s. $6\frac{1}{2}$d. per share on the fully-paid shares.

West India and Panama Telegraph Company, Limited.—The report of this Company for the half-year ended December 31 states that the amount to credit of revenue is £36,141, against £43,978 for the corresponding half of 1890, the expenses being £25,296 against £21,898, leaving a balance of £10,845, which, with the amount brought forward, makes a total of £16,100. It is proposed to pay the first and second preference dividends of 6s. per share, and a distribution on the ordinary shares of 6d. per share, tax free, £2,122 being carried forward.

Companies Registered during March.—The following electrical companies were registered during the past month:

Corlett Electrical Engineering Company, Limited, £10 shares	£10,000
Electric Cycle Syndicate, Limited, £1 shares	3,000
Madras Electric Tramways Company, Limited, £1 shares	100,000
Western Counties Electric Light and Power Syndicate, Limited, £50 shares	25,000

Liverpool Telephones.—Tenders are required for the execution of certain electrical work, consisting of wires and instruments for about 95 miles of telephonic communication, with alarm bells, and other electrical appliances required between Liverpool and Lake Vyrnwy, and between Liverpool and Rivington, for the Corporation of Liverpool. Drawings may be obtained at the office of the water engineer, Mr. J. Parry, M.I.C.E., Municipal Buildings, Liverpool. Sealed tenders must be addressed the Town Clerk, Municipal Buildings, Liverpool, and delivered at his office before 12 noon on June 7th. The person or persons whose tender may be accepted will be required to execute a contract, to be prepared by Mr. G. J. Atkinson, town clerk.

PROVISIONAL PATENTS, 1892.

MAY 2.

8242. **Improvements in and connected with electrically-propelled vehicles.** Friedrich August Haselwander, 70, Market-street, Manchester. (Complete specification.)

8258. **Improvements in carrying or supporting electric collectors.** Michael Holroyd Smith and Thomas Perceval Wilson, 55, Chancery-lane, London.

8265. **An improved globe or shade holder for electric, gas, or other lamps.** William Howard Ingall, 37, Chancery-lane, London.

8267. **Improvements in electrical circuit arrangements and apparatus for telegraph message signalling.** Frederick Thomas Hollins, Saltley House, Forest Drive, Leytonstone, Essex.

8268. **Electrical steering gear.** George Sylvester Grimston and Alfred Herbert Dykes, 28, Southampton-buildings, Chancery-lane, London.

MAY 3.

8294. **The electric light advertisement.** John Charles Baynton Taylor, Paradise Cottage, Holloway, Bath.

8367. **Improvements in incandescent electric lamps.** John Robert Hughes, 21, Finsbury-pavement, London.

8385. **Improvements in electricity meters.** William Frederick Taylor, Boswell Court, Croydon.

8397. **Improvements in the method of and apparatus for transforming and distributing electric currents.** Friedrich August Haselwander, 70, Market-street, Manchester. (Complete specification.)

8399. **Electrical or galvanic braces.** Joseph William Paramore and Henry Theaker, Bank-buildings, George-street, Sheffield.

8408. **Improvements in electric incandescent lamps.** Isidore Clifford, 61, Chancery-lane, London.

8447. **A new or improved holder for the globes or shades of electrical, gas, and other lamps.** Richard George Evered, 7, Staple-inn.

8452. **Improvements in driving certain machines by electromotive power.** Arthur Chapman, Vulcan Iron Works, Spencer-street, Rhodeswell-road, Limehouse, London.

8463. **Improvements in electric arc lamps.** Carl Coerper, 45, Southampton-buildings, London. (Complete specification).

MAY 5.

8493. **Improved telephone transmitter.** Richard Whitehead and Alfred Doxey, 7, Well-road, Heeley, Sheffield.

8507. **Electric time-check, call-bell, and registering apparatus.** Charles Miles, 6, Wells-road, Totterdown, Bristol.

8529. **Improvements in galvanic batteries.** Walker Moseley, 82, Montpelier-road, London.

8535. **Electrical hose signalling apparatus.** William Fowler, 52, Chancery-lane, London. (Complete specification.)

8537. **Improved electric light switch.** William Edward Langdon, Electrical Department, Midland Railway, Derby.

8556. **Improvements relating to alternating-current electric machinery.** Octave Patin, 45, Southampton-buildings, Chancery-lane, London

MAY 6.

8576. **Improvements relating to the measurements of electric currents.** Edward Howard Percy Humphreys, 39, King's-road, Chelsea, London.

8611. **An improved electric alarm for showcases.** Rudolph C. Kruschke, 55, Chancery-lane, London.

8638. **Improvements in electric mains.** Thomas Tomlinson, 24, Southampton-buildings, Chancery-lane, London.

8642. **An improved holder for holding shades or globes of electric, gas, or other lamps.** Ernest Francis Carpenter, 37, Chancery-lane, London.

MAY 7.

8663. **Improvements in the cores of electromagnets for motors and other purposes.** Henry Francis Joel, 44, Lavender-grove, Dalston, London.

8706. **Improvements in electrical fittings, such as ceiling roses and cut-outs.** Stuart Archibald Moore, 46, Lincoln's-inn-fields, London.

8720. **Improvements in electric meters.** Walter Thomas Goolden and Sydney Evershed, Woodfield Works, Harrow-road, London.

SPECIFICATIONS PUBLISHED.

1891.

6485. **Dynamo-electric, etc., machines.** Gravier.

6730. **Dynamo-electric machines.** Mordey.

8323. **Thermo-electric apparatus.** Goldsmid. (Riatti.)

9291. **Electric arc lamps.** Bishop.

9734. **Dynamo-electric machines.** Aldred.

10,082. **Voltaic batteries.** Jablochkoff.

10,256. **Electric bells.** King and Mendham.

20,864. **Electro-medical coil and battery.** Hodgkinson and Tompsitt.

1892.

871. **Electric cables.** Lake. (Brooks.)

4764. **Electric wire insulators.** Lake. (Hammond.)

4773. **Electrical conductors.** Redfern. (Bergmann.)

4816. **Electrical cables.** Fairweather. (Phillips.)

4961. **Electric slide resistances.** Muirhead.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{1}{4}$
— Pref.	—	$2\frac{3}{8}$
India Rubber, Gutta Percha & Telegraph Co.	10	$20\frac{1}{2}$
House-to-House	5	$5\frac{5}{8}$
Metropolitan Electric Supply	—	$8\frac{3}{8}$
London Electric Supply	5	1
Swan United	$3\frac{1}{2}$	$4\frac{1}{4}$
St. James'	—	$8\frac{5}{8}$
National Telephone	5	$4\frac{1}{2}$
Electric Construction	10	$6\frac{1}{4}$
Westminster Electric	—	$6\frac{9}{16}$
Liverpool Electric Supply	5	$5\frac{1}{4}$
	3	$3\frac{1}{8}$

NOTES.

Bristol.—The district of St. George's, Bristol, is thinking of having the electric light.

Larne.—The permanent machinery of the central station at Larne is being started this week.

Southampton.—A new pier has been opened at Southampton and will probably be lighted by electric light.

Niagara.—Prof. Forbes, we hear, has been visiting Niagara, with a view of reporting upon the proposed power transmission scheme.

Blackpool.—An installation of electric light has been put down at the Blackpool Aquarium by Messrs. Heenan and Froude, of Manchester.

Rio Janeiro.—According to the *Rio News*, the telephone line between Rio and San Paulo has been partly constructed, and, so far, works well.

Electricity v. Cable.—The St. Louis cable tram system is now, after some months' active labour, entirely changed to an electric traction system.

Huddersfield.—A clerk of works is to be appointed, at a salary of three guineas a week, to superintend the erection of the electric light station at Huddersfield.

Wolverhampton. — We understand that Wolverhampton is moving with regard to the electric light, and that Mr. Preece has been called in to advise.

Exetor.—The borough surveyor of Exeter has prepared a long report on electric lighting of the city, which has been printed and circulated for the consideration of members.

Walsall.—Mr. F. Brown, M.I.C.E., has been called in to advise and report as to the various tenders sent in, respecting a scheme which is to be carried out in reference to electric lighting.

Harwich.—Nothing further has yet been done with reference to the electric lighting of Harwich, but it is probable that the Corporation may arrange to transfer their powers to a private company.

The Engineering Exchange in Billiter-buildings has been opened. A dinner will be held at the London Tavern, Fenchurch-street, on May 25, at 6 p.m. (11s. 6d.), and a smoking concert is to follow.

Barnet.—The arbitration case of Joel *v.* The Barnet Vestry is progressing to an end. Expert and other witnesses have been examined, and the case is adjourned to Monday, when possibly a decision will be made.

Colour Photography.—As numbers of our readers have been interested in Mr. Ives's colour photographs, it may be well to mention that he will give a lecture before the Society of Arts on this subject at 8 p.m. on Wednesday next.

Azores Cable.—The decree of the Portuguese Government has been published annulling the contract entered into with the British company for laying the cable to the Azores, and ordering the undertaking to be put up for public tender.

Medical Electricity.—According to an Aberdeen paper, a Prof. Geismar has been curing toothache, deafness, and even blindness by means of electricity! He must be a peculiarly able manipulator of nerves, or his audience peculiarly credulous.

Sophia.—A Sophia correspondent of *L'Industrie Electrique* says that the Parisian bankers Ellicott et Cie. are preparing to issue a loan of 6,000,000f. at 78 per cent. for the establishment of electric light in the municipal buildings and baths of Sophia.

Southwark.—At the meeting of the St. Saviour's Board of Works last week, the clerk read a letter from the Board of Trade, expressing their satisfaction that the Southwark Electric Lighting Company were in a position to carry out the order.

Navy Projectiles.—The *Daily News* points out that the parliamentary returns just issued shows that the Admiralty have gone to foreign manufacturers for various requirements, amongst which are £3,000 worth of mirrors for electric light projectors.

Nottingham.—The Electric Lighting Committee of Nottingham have decided to appoint Mr. H. Talbot to the position of electrical engineer to the Corporation, at a salary of £300 a year. Mr. Talbot has been until now the engineer of the Chelsea Electricity Supply Company.

Beverley.—The owners of two large works near Beverley are thinking of introducing the electric light. Mr. Dixon, at the last meeting of the Town Council, moved that the price of gas be reduced 5d. per 1,000ft. from July next, as a timely concession, but his motion was defeated.

London-Bordeaux Telephone.—The telephone between Paris and Bordeaux will be in working order on June 1, and a special service will be instituted (says the Paris correspondent of the *Chronicle*) to transmit messages from the latter place and most of the large French towns to London.

Training Ship.—The London School Board have voted the sum of £1,500 for provision of a boiler and electric light installation on board the training ship "Shaftesbury," on the Thames. The installation will comprise 200 lamps. The tenders have been invited and received, but the contract has not yet been settled.

Halifax.—The committee of the House of Commons presided over by Mr. Leonard Courtney have passed unopposed a Provisional Order Confirmation Bill, which authorises the Corporation of Halifax to undertake the lighting of the borough with electricity. In due course this will be presented for third reading.

Bath.—The electric light company propose to make certain additions to the existing machinery in their central station in Dorchester-street, so that a continuous 24 hours' supply of light can be given from the 29th September next. At present the current is turned off between the hours of 10 in the morning and 2 in the afternoon.

Royal Society.—Among the candidates for election as Fellows of the Royal Society, we understand, are the names of Prof. J. Fleming, of the University College, and Lieut.-Colonel Armstrong, formerly assistant-instructor in submarine mining and electricity, and inspector of submarine defences, military ports, and coaling stations since 1884.

Berly's Electrical Directory, 1892.—We have received the new edition of this admirable directory from the new proprietors, Messrs. Alabaster, Gatehouse, and Co. This is the eleventh annual publication, and has been thoroughly revised. The price is reduced to 4s. We hope to deal at greater length with this volume in our next issue.

Bristol Channel.—The Trinity House authorities have communicated to the Bristol Docks Board their intention to carry out a scheme for the better lighting of the channel. There will be new lights at Black Nore Point, and a new lighthouse on the Foreland, and another light vessel eastward of the Nash lights, one of which is to be abolished.

Dundee.—We give elsewhere Prof. Kennedy's report on the proposed scheme for the electric lighting of Dundee

on the three-wire continuous-current system with accumulators. On Tuesday the Gas Commission adopted this report, and it was resolved to take in contracts for boilers, steam piping, steam engines, dynamo machines, batteries, and street mains. The work will be gone on with without delay.

Mansion Lighting.—Messrs. Drake and Gorham are adding Rookwood, Llandaff, the residence of Colonel Sir Edward Hill, K.C.B., M.P., to their long list of country house installations. The motive power will be an Otto gas engine driving an eight-unit dynamo, which will supply current for charging a battery, and also for working a large pump. The installation is to be at work by the beginning of July.

H.M.S. "Resolution."—A new battleship, built by Palmer's Shipbuilding and Iron Company, will be launched next week at Jarrow. The "Resolution," as the ship is to be christened, will be lighted throughout by electricity, with an installation of about 700 electric lamps, and will also be equipped with four electric search-lights of 25,000 c.p., each of which will be worked by dynamos under protection.

Books Received.—We have to acknowledge receipt of the following—viz., "The Wire and the Wave: a Tale of the Submarine Telegraph," by J. Munro, published by the Religious Tract Society, 56, Paternoster-row; and "The Art of Teaching and Studying Languages," by François Gouin, translated from the French by Howard Swan and Victor Bétis; London: Geo. Philips and Son, 32, Fleet-street.

Hull.—The contract from the Hull Corporation for the construction and laying of electric mains in the streets in the prescribed area has been awarded to Messrs. Crompton and Co., Limited. The tender comes to over £8,000. The work will be commenced at once, and Mr. B. H. Jenkinson, who has lately completed the Southampton mains, has the carrying out of the contract on behalf of Messrs. Crompton.

Typewriters in Post Offices.—We recently mentioned the very great extension in the use of typewriters for the telegraph operators in the American post offices. We hear that a similar extension is taking place in the British post offices, and that already considerable numbers of typewriters are in use. With the perfection of the telephonic telegram system the use of typewriters will tend to become universal in the telegraph offices.

Switchboard for Glasgow.—Tenders are invited for providing and erecting a switchboard, with connections, at the Glasgow central electric lighting station, for the Glasgow Gas and Electric Lighting Committee. Plans and specifications may be seen and forms of tender obtained on application to Prof. Kennedy, 19, Little Queen-street, Westminster. Sealed offers will be received by Mr. J. D. Marwick, town clerk, City Chambers, George-street, Glasgow, up to 24th inst.

Guildford.—The Guildford Town Council have had before them the question of carrying out the public lighting of their town by electricity. The lease of the Guildford Mill expires shortly and is advertised by the Poyle Trustees, to whom the mill belongs. If the Town Council think of utilising their water power, the matter must be therefore settled at once. The Corporation, who have the welfare of their town much at heart, are determined to give full consideration to the project.

Waste Products.—Mr. Wigham Richardson states that Mr. Mond (of Brunner, Mond, and Co.), who leads the smoke from his chimneys into a waterspray chamber, obtains four tons of sulphate of ammonia for every 125 tons of coal burnt. The waste product of this amount of coal is worth somewhere about £50. If results such as these can be practically obtained, the waterspray condenser might prove just as useful an adjunct to electrical engineers as a similar arrangement has proved to gas engineers.

Board of Trade Laboratory.—The Board of Trade experts have been working with assiduity at their task of determining with accuracy, on their standard ampere-balance, the exact weight of the attractive force under stipulated conditions of one ampere. This weight, when settled, will be adopted as the legal unit, and we understand that they have, after several very careful experiments, come within exceedingly small mathematical limits of the desired accuracy. The published results, we fancy, may be expected before very long.

Electric Light in the Vatican.—A project is on foot for lighting the Pope's private chapel, and, indeed, the whole of the Vatican, with incandescent lamps. His Holiness has not yet sanctioned the innovation, but has it under consideration. There are not wanting vigorous and powerful opponents to the scheme, which, on the other hand, has the support of several high ecclesiastics, who fail to see why the Vatican should not advance with the times in this respect, more especially as the offices of the Pope are already fitted with the telephone.

Blackburn.—It is rather astonishing in a town the size of Blackburn to find it reported that the prospective use of the electric light is inconsiderable. Yet such is the result reported by the Corporation, who have undertaken a canvass of the principal tradesmen in the centre of the town. A very moderate demand was reported, and it is thought improbable that the Corporation will undertake the light. It will, therefore, be open to any private company to tap this source of revenue after August, if they so desire, and it is not likely the opportunity will be allowed to pass.

Silent Fans.—The Duke of Edinburgh in his recent speech stated his admiration for electric fans, but said those he had seen were far too noisy. The Keys' Electric Company, in reference to our note on this subject, write to say they have a whole series of electric fans running at their showrooms, in Charing Cross-road, from the smallest size up to ½ h.p. These can be seen and felt, but not heard—they are absolutely silent. The Czar of Russia should be induced to change his system of fans on board his yacht, so that the Duke might recommend the wares without fear of distressful noise.

Electric Poles.—The writer of the series of articles on electric traction in the *Glasgow Herald* mentions that a very useful and comparatively elegant design of standard pole has just been introduced into this country in the shape of the American Milleken patent pole. It is of open ironwork, and looks rather well. It can be fitted with long brackets of light design, and altogether looks a good thing. A description and illustrations of the pole are given in a recent number of the *Tramway and Railway World*, and Messrs. Dick, Kerr, and Co., London and Kilmarnock, are the British manufacturers.

Bradford Tramways.—The electric car at Bradford, which is to be run a few weeks experimentally, began carrying passengers at penny fares on Monday. The public at first were distrustful, only 187 paying passengers venturing. Since then patronage has been greater. The object of the experiment has been to demonstrate the possibility of running on such gradients, and to determine the cost of running. The enquiry is being carried out with a view to the adoption of electric traction on the

Wakefield road tram lines. The low limit of the Board of Trade, four miles an hour, is maintained with the greatest ease.

Willesden.—At their last meeting the Willesden Local Board received a large deputation as the result of the meeting reported last week. Mr. Beavis, as spokesman, read a speech complaining of the excessive charges of the gas company, and advocated the public supply of electric light by the Local Board. Mr. Beavis doubted the power of the River Brent for use with a turbine, as suggested at the meeting. He was asked for a copy of his address for the consideration of the Board, and promised to supply this. The chairman said the Local Board were already considering the question of electric light, and were not in favour of granting powers to a company.

Station Indicator.—We are told that a simple indicator for showing the names of stations in trains has been worked out by two of the inspectors of the Local Government Board. Hitherto the difficulty in the way of adoption of such an arrangement has been the expense. It is understood that the simplicity of the design obviates this objection, and the cost of manufacture being only a few shillings each. The indicators are worked with six dry cells, and the name of the next stopping place is indicated in every compartment. The inventors are Messrs. Brydone and Chattaway. If proved practical, this invention ought certainly to come into extensive use.

Telephonic Telegrams.—A name will soon be wanted to express a telegram sent by telephone. The thing itself is within measurable distance. The Postmaster-General last Friday had an interview with a deputation from the Associated Chambers of Commerce, and stated that as to the Government management and control of telephones, the experience of the United States showed that efficiency and success were not dependent upon the condition of the general adoption of underground cables, but the increased general powers about to be sought in a Bill by the Government would doubtless lead to an improvement of the telephonic service.

Isle of Man Exhibition.—A vast number of business men from Yorkshire and Lancashire take their summer holidays in the Isle of Man, and we suppose it is the consideration of this that has led to the idea of holding an exhibition in Douglas from July to September. The buildings and ground will be lighted by electricity, and an additional reason is given for exhibition as it is (until now) the only exhibition organised in Great Britain for 1892. Section 16 is devoted to electrical engineering. The manager is Mr. Henry W. Pearson, Belle Vue, Douglas, Isle of Man. The steamers from Barrow and Liverpool are claimed as literally the swiftest vessels afloat.

Electric Welding and Eyesight.—A note has been going round the technical press, stating that cases of loss of eyesight have been met with in the Benardos system of electric welding. We have written to Messrs. Lloyd and Lloyd with reference to this point, and they inform us that they do not know of any case, either in this country or elsewhere, of "blue" glasses being used by the licensees of the Benardos process for the protection of the eyesight of the welders. Their own experience and that of their licensees, extending now over several years, does not include one case of injury to eyesight. Of course the glasses should be properly selected in colour and density for the purpose.

Cambridge.—With regard to the electric lighting of Cambridge, order is being gradually evolved from chaos. It will be remembered that Prof. Garnett was appointed consulting electrical engineer in May, 1891, and on May 17 last the Town Council decided not to proceed with the work, and to hand over the powers contained in the provisional orders to a company. To recompense Prof. Garnett for his work the Council have voted that he be offered 100 guineas, such amount to include travelling and other incidental expenses, while at the same meeting they adopted the report of the committee for the erection of an electric light station in Thompson's-lane by the Cambridge Electric Supply Company.

Electric Fans at Vienna.—The ventilation of the theatre in the Musical and Dramatic Exhibition at Vienna has been carried out by the Blackman Ventilating Company, Limited, 63, Fore-street, London, E.C., by means of a Blackman fan, 72in. diameter, driven by belt from a motor, and blowing in fresh air under all parts of the ground floor. The impure air is removed by eight electric Blackmans, distributed in various parts of the house; the current driving these fans is at a pressure of 150 volts, and at the opening of the exhibition on Saturday last, Mr. Watel, the company's engineer, and the inventor of the electric Blackman, had the honour of being presented to the Emperor during his inspection of the building.

Units and Newspaper Electricity.—Mr. Preece's lecture at West Hampstead was very well attended, many having to be refused admittance, but not all understood even the simple technical terms used. A Hampstead paper speaks about people in the future "paying for electricity not by the number of 'bolts,' but by a combination of them termed 'wats'"; and further on it says "a kettle will boil with 100 'bolts' of electric light." It was Mr. Preece, we believe, who proposed the "bot" and other names for the unit of supply; but the above examples are quite sufficient to show the difficulty of the public in understanding even the best-known technical terms when these convey no distinct meaning other than that arbitrarily associated with them.

Telephone Charges at Sheffield.—The National Telephone Company, whose recent revised scale of charges for Sheffield led to great indignation on the part of their subscribers, have now submitted a fresh tariff which they hope will conciliate their customers. They propose to charge £8 per annum for the mile and a half radius, £10 for the two-mile radius, and an additional £2. 10s. for every half mile beyond this limit; and £7 for private houses within the two-mile radius. The Subscribers' Committee had these proposals before them on Wednesday, but have not signified approval or disapproval. Mr. A. R. Bennett, on behalf of the New Telephone Company, attended, and stated the rates, which are very low, upon which his company were prepared to commence an exchange in Sheffield.

Electricity at the Opera.—Two innovations were observed by those who attended the brilliant opening of the season of the Royal Italian Opera on Monday, says the *Daily News.* In the first place, a theatrophone was hung at the side of the prompter's box, communicating with the manager's room, and enabling Sir A. Harris to hear what is going on upon the stage even while he is transacting business in his private sanctum; and in the second place, incandescent electric lamps, placed in half the chandeliers on the first two circles, replaced the wax candles which from time immemorial have been used at Covent Garden during the grand season. At present the remainder of the chandeliers are lit by gas, but as the season advances it is hoped that the hotter illuminant will be entirely dispensed with.

Electrical Art Fittings.—A new departure in the field of art applied to electric incandescent lamp fittings has been introduced by Messrs. John Davis and Son, of 118, Newgate-street, London, who are the sole agents for

the beautiful productions to which we call our readers' attention. The electroliers, wall brackets, table lamps, cornice sprays, and other fittings are composed of floral decorations, produced in natural tints, the flowers and leaves being artistically enamelled upon metal. The designs, of which there are many hundreds, vie with each other in elegance and artistic merit. These fittings may be considered as unique and are admirably adapted for drawing and dining rooms, theatres, and other artistically-fitted rooms. We understand specimens may be inspected at the offices of Messrs. Davis, in Newgate-street.

A Rival Illuminant.—The absence of orange rays in the electric arc has made inventors turn to other sources of light to procure a thoroughly satisfactory lighthouse illuminant. The latest is by a German inventor, who drives air through pumice-stone impregnated with benzene, and then through fine magnesium powder, which is forced upwards by the benzene gas through a nozzle. A light of 400,000 c.p. is said to be obtained. The apparatus goes into a small space, and, if the claims are correct, the light may form a powerful rival to the electric arc for coast service. Whether any illuminant will ever be able to oust the electric light is extremely doubtful, but there is certainly a requirement to be fulfilled in the greater piercing power needed in fogs, and the subject of the proper treatment of the arc for this purpose is well worthy the study of some of our theoretical experimentalists.

Electric Light on the Battlefield.—A Gratz telegram to Reuter on Tuesday says: "Last night a new experiment of great interest was carried out here. The difficulty of searching for the wounded on the night after a great battle has been one which has long occupied the attention of military reformers, and the Army Medical Service in Austria has determined to try how far the electric light may be utilised for this humane end. It has been found that powerful search-lights with reflectors are very effective on open ground, but in cases where the battle has raged over a wide extent of country, or where the fighting has occurred amid woods and brushwood, such luminants are not of much use. Hence it was resolved to experiment with the electric light in a new form. The men of the Army Medical Service were sent out last night with portable electrical lanterns, which were fed by accumulators contained in their knapsacks. The experiment was fairly successful, and it is likely to be repeated."

Nelson.—A Local Government Board enquiry was held at the Nelson Town Hall on Tuesday with regard to an application made by the Corporation for powers to borrow £10,000 for the purpose of electric lighting. The town clerk, in his statement, said the main object of the Gas Committee in deciding to work an electric light installation was to use up all the waste heaps from the furnaces of the gas works. Alderman Hartley, the chairman of the Gas Committee, said they proposed to work the electric light scheme from the gas works. A 60-h.p. steam engine would be used, and they would put down one 600 16-c.p. light dynamo. The scheme provided for the laying down of cables from the gas works, and the mains would be of sufficient capacity to supply double the light now used. The Council had already entered into an agreement with a number of tradesmen for nearly 500 lights to be supplied for three years. Mr. William Foster, the gas manager, said the plans were suitable for the present requirements of Nelson.

Omnibus Lighting.—The electric light, among other conquests, is gradually making its way for use in the lighting of omnibuses in London. We recently reported the use of the Bristöl pocket lamp for the inspectors on the London General Omnibus Company's service. The lighting of the 'buses themselves was not touched in that experiment, but we learn that this question is now being dealt with in a practical manner. The lighting of the omnibuses, at any rate of the great lines, is in the hands of Mr. J. Willing, jun., of 125, Strand—not the same firm, by-the-bye, as the advertisement contractors. Recently after trials of several systems, the lithanode cells of the Mining and General Electric Company have been selected, and the work of experimenting and fitting up several omnibuses has been carried out by Mr. Willing, under the superintendence of Mr. Thomas Hymns. Two or three 'buses are already running continually fitted with the electric light, and the company express themselves exceedingly pleased with the result. The lamps have already proved so successful, although as yet no special arrangements have been made for charging and changing the batteries, that it is expected the system will at once be largely extended.

Midland Railway Installation.—The directors of the Midland Railway Company, in determining upon the establishment of the large installation of electric light at Derby recently mentioned, have been influenced mainly by the desire to improve the hygienic conditions under which large numbers of their staff have to work, frequently till late hours in the night. Mr. W. Laugdon, who has the electrical engineering department of the Midland Railway under his care, informs us that they are laying down lighting installations in the goods yards and warehouses at Lawley-street, Birmingham; Hunslet, Leeds; and the Wicker-yard at Sheffield. They have already established similar installations at the new goods depôt at Worcester Wharf, Birmingham, and at Somers Town, London, and also at Bradford. At Bradford the lighting of the station and hotel, as well as offices and refreshment-rooms, is entirely effected by electrical energy. The hotel at St. Pancras, as also the Adelphi Hotel at Liverpool, is also lighted throughout in a similar manner. When the whole of the arc lighting installations are in operation, which will probably be the case towards the autumn of the present year, the Midland Railway Company will have about 1,000 lights running. The Thomson-Houston system is that used throughout for arc lighting work.

Electric Bicycles.—One of the questions an electrical engineer is most troubled with amongst his non-technical friends is, when may they expect to see electricity applied to a bicycle or tricycle. Some little time ago Mr. Vaughan Sherrin, of Ramsgate, tackled this problem; and with a primary battery of peculiar construction, which generated its own oxygen in the solution, and earned the encomiums of Prof. S. P. Thompson, he constructed a bicycle which would, it was stated, run for 50 miles or so in nine hours at a cost of eighteenpence. At a demonstration of this battery in the City-road we had an opportunity of riding in an electric bath chair, which wobbled its way somewhat noisily up hill and down dale in a sedate and novel fashion. Electric tricycles were promised at £30 complete, but we have not seen them yet, though they may come. Meanwhile, another inventor, Mr. Graffiny, we see from a note in a Folkestone paper, has busied himself with the same fascinating problem, and has produced, so it is said, an electric bicycle that can do the trip from Land's End to John O'Groat's House without stopping to have its batteries refilled. The weight of these when filled with liquid is 44lb.; including this apparatus for motive power, the machine then weighs 155lb. The public would like to see this electric bicycle at the next Stanley show. It is to be hoped experience will not prove the problem still unsolved. We see that the financial papers announce that a small company is to be brought out with a capital of £3,000 for the manufacture of electric cycles.

Aberdeen.—Prof. Kennedy, who was asked by the Gas Committee of the Aberdeen Town Council to report upon the introduction of a system of electricity, visited that city last Saturday, and inspected the areas under the Electric Lighting Bill. He paid a visit also to the gas works and other likely sites for the erection of installation apparatus in connection with the proposed scheme, afterwards meeting the Gas Committee and having a general conversation with them on the subject. Bailie M'Kenzie, convener, presided. Prof. Kennedy, in the course of his remarks, said he was distinctly of opinion that the Corporation should keep the matter of supplying electricity in their own hands, and that he had no doubt whatever that they could both make and sell it at a profit, if desired; but that as no profit was desired by the Corporation, they should be able, in his opinion, to supply it at less than the maximum price provided by the Bill, which was 9d. per unit. He further stated that he had little doubt the proprietors of the principal shops would at once take the electric light, seeing that it was much cleaner and purer than gas, if the installation were but once made. Roughly, and without going into detail, he believed the Corporation would be able to supply electricity at a rate not more than twice the cost of gas, and that, if a large quantity was taken, it might be produced at a figure even less. He stated that he was likely to recommend the low-tension three-wire system, the same as proposed for Glasgow, the two cities being so much alike. Prof. Kennedy answered a number of questions in the course of the discussion, and it was arranged that he should prepare and send in an exhaustive report upon the whole subject, including a statement as to the site he would recommend, the system of distribution he would propose, the area which he suggests the Corporation should start with, and an estimate of the cost of distribution.

Manchester.—Mr. S. J. Smith, one of the inspectors of the Local Government Board, held an enquiry on Tuesday at Manchester into the application of the Town Council to borrow the sum of £150,000 for the purposes of electric lighting and £12,000 for providing a public library for the Openshaw district. Sir John Harwood, called upon to give evidence, said the Corporation had had the question of electric lighting under consideration for the last 10 years at least. He and two other members of the Corporation reported on the electric lighting of the Paris Exhibition, and almost every year since then the Council had looked at the matter to see if they considered the time was ripe for an installation in Manchester. Nearly every part of England in which electric lighting was going on had been visited. In the year 1890 a provisional order was obtained from the Board of Trade and confirmed by Parliament. Since the provisional order was obtained very great pains had been taken with the view of securing that the best possible system should be adopted, advice having been obtained from the most eminent electrical engineers in the country. Dr. John Hopkinson had been employed by the Corporation to carry out the work. He himself thought that the money now applied for was little enough, and that it would have been better to borrow £200,000. The site which had been secured for the generating station was a ground in Dickenson-street, near Portland-street, which had been occupied for many years by the Paving Committee of the Corporation. The station would be near its work, and the site was regarded as otherwise suitable. The contracts which had been already let, and others which would be let shortly, amounted to £78,000. The Inspector: And that is the first instalment only, I suppose. You will have to go on again when that is spent? Sir John Harwood said that was so. Already enquiries for the light had been received from persons outside the compulsory area. Of course, they were not seeking to make a profit out of the scheme in any way. They were only seeking to develop the resources of the city. There was no opposition to the application.

York.—A special meeting of the York City Council was held on Tuesday (Alderman Sir Joseph Terry occupying the chair) to receive and consider a report of the Streets and Buildings Committee (acting as the Electric Lighting Committee), recommending that the Council proceed to exercise the powers conferred upon them by the York Electric Lighting Order, 1890; that application be made to the Local Government Board for sanction to borrow £15,000 for electric lighting purposes; and that tenders be invited for the execution of the work and the supply of plant necessary. The report recommended that the Council undertake the electric lighting of the city, but that before adopting any scheme for the electric lighting of the city the Council assure themselves that it can be extended so as to form a complete scheme, providing an installation capable of effectively lighting the whole area of the city, and, further, that the electric supply station be erected on a suitable site on the Foss Islands, the property of the Corporation. Mr. H. V. Scott moved the reception of the report. Mr. R. E. Crompton, whom the committee recommended should be retained as electrical engineer to the Corporation during the execution of the works, stated, in answer to questions, that Liverpool had paid a dividend on the electric lighting for some years of about 4 or 5 per cent. The St. James's Company, London, paid 10 per cent., and the Metropolitan Company had paid 2 per cent. The best criterion for York was the case of Bradford. That town had borrowed money, had been working for two years, paid the interest, and had a balance to the good. It had been entirely managed by a committee, who were so hopeful of success that they proposed to extend the electric light over the whole town. The longer the light was used per day the cheaper would be the rate. He was informed that the burning hours of York and Bradford would be about the same. The report having been received, Mr. Scott then moved its adoption, and remarked that it was idle for anybody to shut their eyes to the enormous advantage of the electric light as an illuminant as compared with gas. He would not give an opinion as to whether high or low tension was the best. The Council would be under the Board of Trade, and they would see that whatever system was adopted they would have such safeguards as would render the system beneficial to the mode of lighting. Mr. Purnell seconded the motion. Alderman Coning moved that the report be referred back to the committee for the purpose of getting information as to the terms upon which contracting companies can distribute the electric light to the citizens, and that no decision be come to until such terms be reported to the Council. Mr. Procter seconded the amendment, and argued that as only 42 persons had promised to take the light it was not fair to saddle the remainder of the citizens with the cost. At present electric lighting was in its infancy, and it was not for corporations to experiment with the ratepayers' money. After considerable discussion as to the advisability of allowing a private company to undertake the lighting of the city for a number of years, Mr. Crompton said electricity can be sold as cheaply as gas if produced on as large a scale, but that could not be expected for some years. The amendment was then put to the vote, when 8 voted for, 15 against, and 5 remained neutral. The original motion adopting the report of the committee was then carried by a large majority.

THE CRYSTAL PALACE EXHIBITION.

THE PILKINGTON-WHITE METER.

BY W. J. HAMMER.

Of the making of electrical meters there seems to be no end. One of the most interesting types which has just been brought to the notice of the public is a meter shown at the present time at Stand 62 in the Crystal Palace

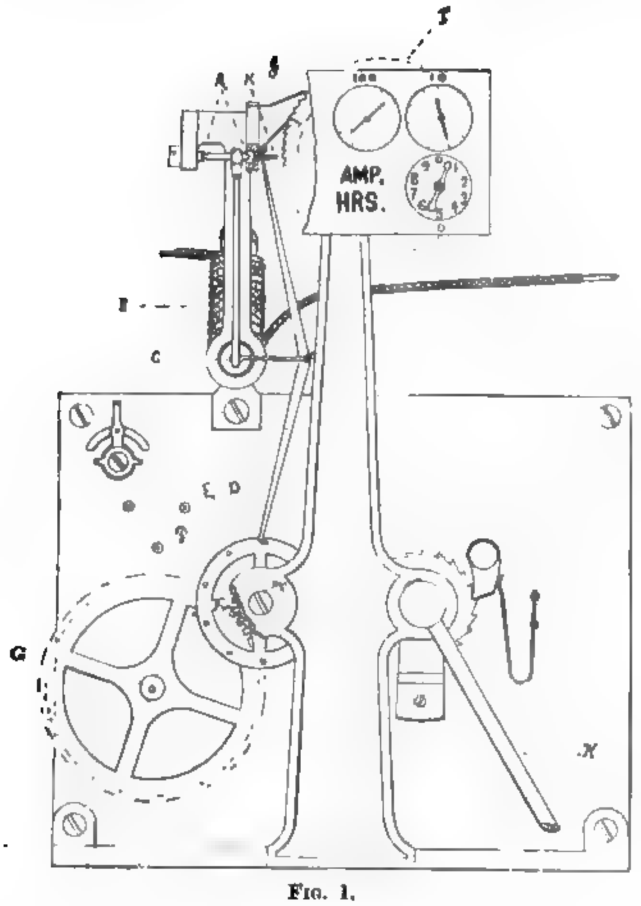


FIG. 1.

Electrical Exhibition. It is the invention of Messrs. H. M. Pilkington and R. S. White, of Brooklyn, U.S.A. These gentlemen have been for years working in connection with the meter departments of the various Edison companies in America, and have themselves constructed a large number

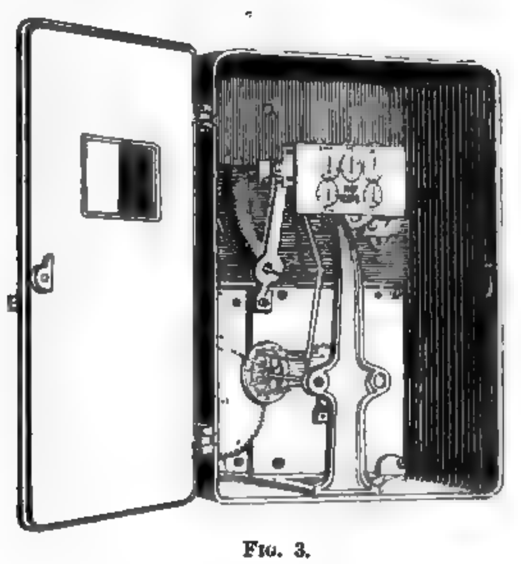


FIG. 3.

of meters, of which the one referred to in this article is the final result. It has been brought to the attention of the principal electrical engineers and companies in America, and been very highly spoken of. It possesses the advantages of simplicity in construction, economy in first cost, and in its operation, and compactness and portability. It gives a reading direct in ampere-hours, and can be sealed up as demanded by the Board of Trade, requiring attention but once a month; is suitable for any currents, alternating or continuous; introduces no drop upon the line; requires no electrical power to operate it; is not affected by short circuits, and being thoroughly encased in iron is ensured the freedom from outside influence; it needs no temperature corrections, and when in use upon continuous currents it may be reversed, as frequently practised, without affecting the reading. The one shown at the Crystal Palace has a capacity of five

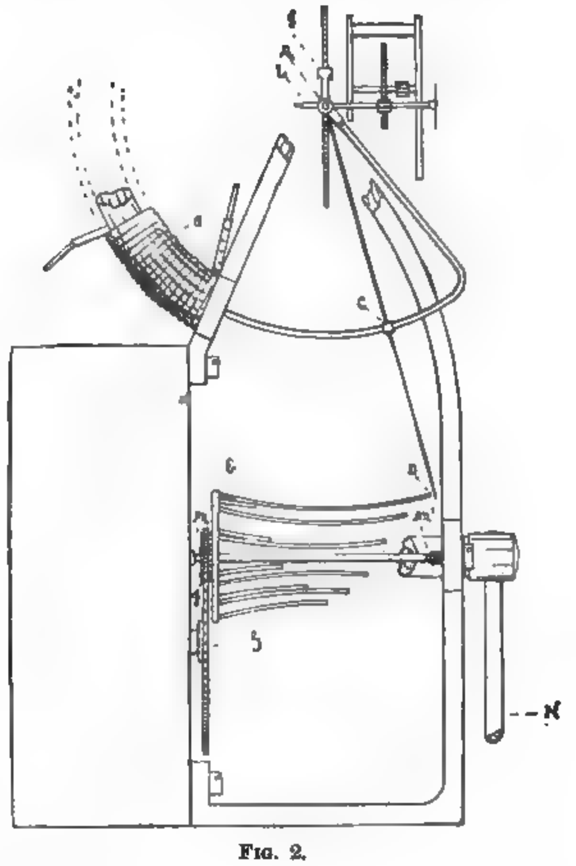


FIG. 2.

amperes, although they are made of any capacity desired, one standard size of case being used for all capacities. This meter has been patented in the United States, Canada, Great Britain, Germany, France, and Belgium. It has already been shown to a number of prominent electrical engineers in this country and met with their approval. The inventors

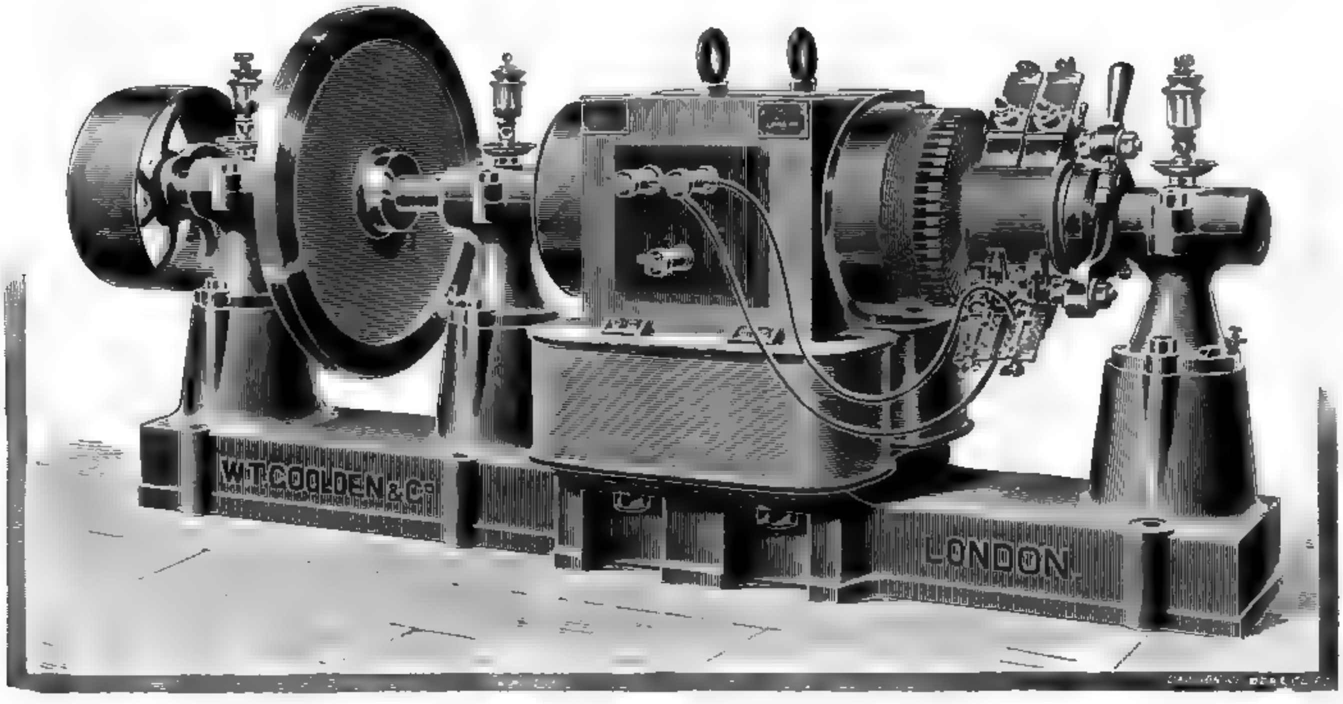
FIG. 4.

have employed the simplest and best-known elements in use. Millions of clocks in daily use bear their own testimony to their reliability. A gravity ammeter constructed upon a solenoid principle, with a very fine core of soft iron, has been extensively used, especially in the United States, and its simplicity and efficiency are so well known

as to need no further explanation here, and the aim of the inventors of this meter has been to form a reliable mechanical connection between these elements with as little complication as possible.

In the accompanying illustrations Fig. 1 shows a front view of the mechanism, and Fig. 2 a side view, whilst Figs. 3 and 4 show the meter as it actually appears. A 40-day clock in a dust-proof case drives by gear, G, and pinion, F, the disc, E, which carries curved pins and D, which disc is mounted on a phosphor bronze shaft centred at M and M[1], Fig. 2. At B is an ammeter solenoid; swinging from centres A is its light soft iron core, carrying at C a fixed bracket, at the outer end of which is freely pivoted a light lever. This lever is forked at the upper end to embrace the steady pin, K, and has a pawl, J, engaging the ratchet wheel, I, of a dial train. The action is as follows: The movement is wound by removable crank key, H, and for 40 days turns disc E around at the rate of five turns an hour. In this disc is set a pin for each half ampere of the meter's capacity, making in this case 10 pins. These are of various lengths, corresponding to the calibration of the instrument. When, say, half an ampere is passing on the coil, B, the ammeter moves and carries the lever to a position where it will be struck by the first pin, D, Fig. 2, once in every revolution of disc E. For every additional half-ampere the arm will move over further, and another pin will come into action, until at five amperes the full number come into play. It will be readily seen that the lever, by being pivoted on bracket, C, and guided at centre, K, forms an integral part of the ammeter core, at the same time possessing its own plane of rotation at right angles to the latter. Therefore, when the pin D, moving to the left, carries the lower end of the lever in the same direction, the upper end, by pawl, J, advances the ratched wheel, I, a distance of one tooth, then D releases the lever and it drops by gravity into position to engage the next pin. Thus, at five amperes, the lever will transmit to the wheel 10 impulses per revolution of disc, or 50 per hour. This wheel has 100 teeth, and is geared even with the unit's dial, so 50 impulses mean half a revolution of unit's dial, or five ampere-hours. The lever being retained only a few seconds by each pin, is always ready to take up a new position as the load is varied. Supposing the load to drop to one ampere the ammeter falls back, and two pins will only engage the lever, recording thereby 10 teeth in an hour, or one ampere per hour.

The accompanying illustration shows the Goolden dynamo, manufactured by Messrs. W. T. Goolden and Co., of Woodfield Works, Westbourne Park. The illustration belongs to the series of articles by Mr. R. W. Weeks on the continuous-current dynamos at the Palace. The particulars and sizes are referred to on page 366, April 15th.



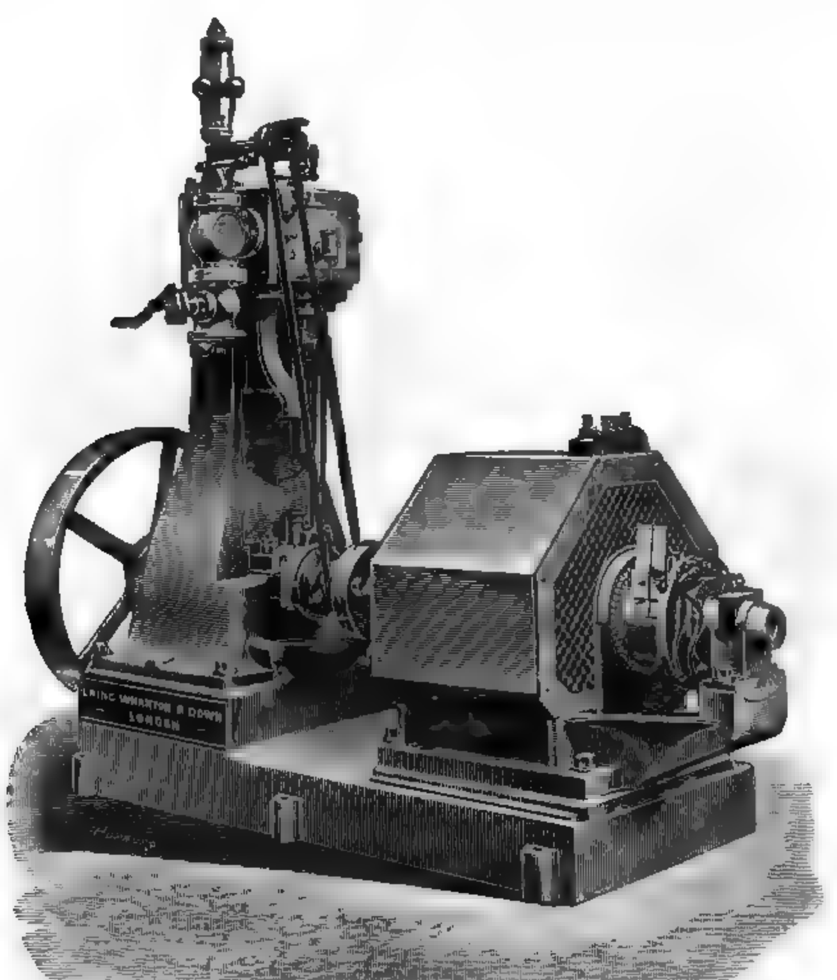
Goolden and Co.'s Dynamo.

The exhibit of **Messrs. Laing, Wharton, and Down,** in the Entertainment Court, is one which attracts considerable attention. In the first place, it is self-contained, having a large space to itself, comprising a complete set of electric lighting apparatus—engine, dynamos, and motors, lamps and heating utensils—and further, being coupled with distinctly one of the most artistic shows of electric fittings—tables arranged by Messrs. Phillips, the glass and porcelain ware decorators, of Oxford-street. Besides this they have some magnificent specimens of their own production of chandeliers lighted and suspended from the ceiling, and two large cases filled with luxurious examples of electric light fittings, as used by Messrs. Laing, Wharton, and Down themselves in their many installations for houses in the West-end.

The power for supplying current to these lamps is obtained from a fine specimen of the Otto gas engine, high-speed, of nine nominal horse-power. This drives by link belting one of the iron-clad dynamos of a make well known to electrical engineers who visited Frankfort, which Messrs. Laing, Wharton, and Down use in their installations and have christened the "Special" dynamo. The running of the gas engine on full load is very steady, and the even motion of the heavy link belt is a pleasure to the eyes of an engineer in comparison to some of the others. The dynamo gives 120 amperes at 100 volts, though, as a rule, 90 amperes is the output at the Exhibition. This supplies the lamps in the court and part of the electroliers, and it is interesting to note that all the lamps are 8 c.p., showing the suitability of this size of lamp when properly installed for indoor illumination. Looking round amongst the fittings we see a handsome electrolier which once belonged to the Princess of Wales and was hung in Marlborough House, but which was exchanged when the decorations were altered. Another richly-wrought and chased electrolier hung opposite it is a reproduction of one of the ormolu chandeliers used by the Queen at Windsor Castle—a massive and ornate pendant that well accords with the warm glow of the light. Another pendant, glittering with a double radiance, is a cut-glass electrolier fitted with some scores of lamps, whose lights shine and sparkle with prismatic colours amongst the glass. This pendant alone cost over 200 guineas, and would make a fine ball-room centre-piece. In one corner is a wrought-iron fanciful pendant, suitable for a large ancestral hall, fitted with deeply cut-glass reflector; and other brackets of

aluminium and copper are specimens of a style of fitting which the firm have made a speciality. A type of standard first introduced, we believe, by them, is the employment of rosy-tinted sea-shells as shade for the incandescent globe. The shell is neatly mounted on pivots, and by a simple movement can be made to give either a soft general light or a more brilliant direct light for reading, or, again, an upward reflected light for a picture. Speaking of picture lamps, we ought to refer to a simple arrangement for a gallery or picture which Messrs. Laing, Wharton, and Down use in the shape of a polished shell of nickel, just the size of an ordinary lamp, which half encircles the lamp closely, and throws a brilliant light on the picture or engraving. Several of these are shown, and give a very good effect with simple and unobtrusive lamp brackets. Another large electrolier in the opposite corner gives a soft opalescent light from eight or ten dropping lamps hung in globes of iridescent cloth. Two contacts, each with three fine needle points, are pierced through the cloth, making good contact to the set of fairy-lamps hidden in a basket of flowers as decoration to the dining-table.

The show-cases contain many examples of the decorative use of fancy silk shades for the electric light, and some quite exquisite colour harmonies for drawing-room and boudoir are the result. A ceiling pendant in which a silk shade is used to go close to the ceiling with the lamps inside, softening the light of the lamps, is very successful, and various adaptations of oil standards richly wrought and fitted with electric holders, together with art vases mounted for the same purpose, are delightful variations from the ordinary fittings. Many of these are fitted with imitation candles in a simple way: two stout wires project upwards and bear on the top a small Edison screw socket, over this is slipped a white sleeve (the imitation candle), and the little flame-like frosted lamp is then screwed on the top, making a simple



Laing, Wharton, and Down's 60-light Ship Set.

glass, and still another illustrates the now fashionable method of using imitation candles with elongated and twisted lamps as the candle flames. This innovation, again, we believe, was first due to the initiative of this firm.

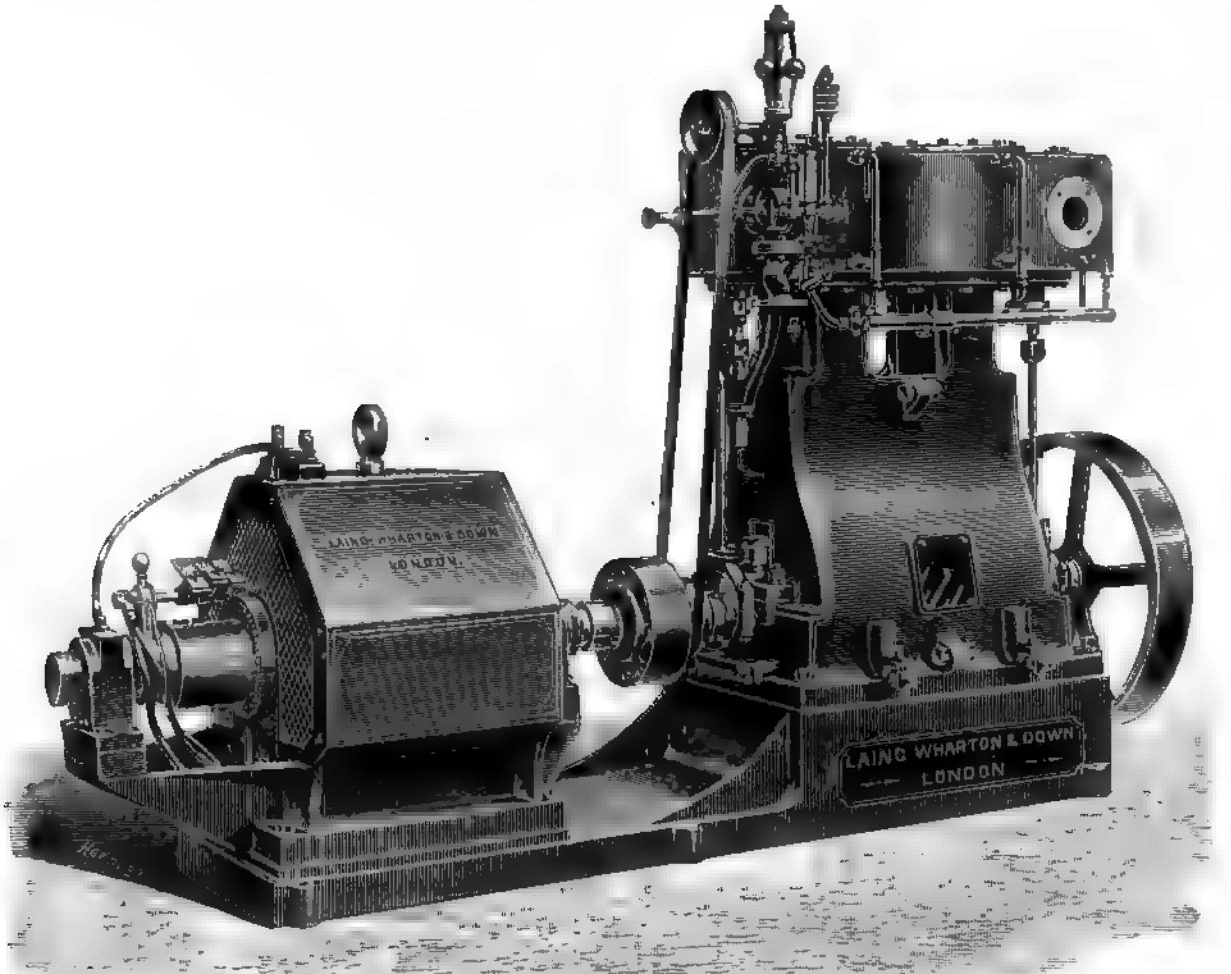
A noticeable lamp, which would evidently well suit a large mansion hall, is made of one of the ancient stage coach lamps, delicately wrought and furbished as was the wont in days of yore; this has been filled with bevelled plate glass and backed with mirrors, and the strong lamp within casts a light which is a peculiar mixture of the new and the quaint. Other examples of the same combination, but more beautiful, are some richly-chased flamboyant brackets of the Old French style. These, denuded of their ancient lights, the candles, are fitted with delicate glass shades and electric lamps, and become a fit appurtenance for the palace of a queen. Connected to one lamp a little further on we see a cigar-lighter, and to another a flat-iron, heated electrically. For table decorations a special provision has been made: two tubes full of parallel wires are let flush into the table, and can be covered with the damask table- and easy junction. A movable bracket for use on a piano is of a type much appreciated by those musicians who are happy enough to have the electric light installed. A heavy weight at one end acts as a kind of base to keep the fitting in place. This weight is covered with an artistic brass exterior, and the bracket projecting therefrom furnished with a delicate silk shade, and this can be placed at any convenient position on the piano or the mantelpiece, connected to a wall socket by a flexible wire. A fine pair of bronzes, representing Mercury and Diana holding electric lights, are also shown, and in the side office, which is tastefully decorated with old engravings, a cut-glass pendant sheds an evenly-distributed light. In this office is fitted a set of Ross improved telephones, which the firm use when any of their installations are required to be supplied with telephones. An amusing set of bell-push contacts is shown close by, consisting of a number of quaint and curiously-carved ivory grotesque faces, the tongues being formed of small projections of ivory dyed red, which act as the pushes—"their words tinkle as do silvern bells."

An exhibit important to army men is that of the Bruce signalling balloons, which are exhibited by Laing, Wharton, and Down. A small balloon sent up to the necessary height has within it one or more electric lamps, which can be flashed on the Morse code by a switch suitably arranged, and connected thereto by wires running up the cord. Sets of shiplighting fittings are also shown, and a large strongly-mounted lantern is constructed for use in fishing—three or four strong lights can be turned on after the lantern is lowered into the sea, and experiments which have been made, and reported upon by us at various times, have tended to show that considerably larger catches of fish can be taken by the use of such a light as an attraction.

It may be remembered that some few months ago we described a penny-in-the-slot arrangement for supplying half-an-hour's electric light to travellers in the railway trains. This arrangement is exhibited at Messrs. Laing, Wharton, and Down's stand in action as used on some of the railways. The light comes on automatically upon pushing the coin into the slot, and can be turned off when done with, if desired, by pressing a button. Some interesting relics of early days are shown in two exhibits—one of these consists of two of the original Swan lamps, numbered 9 and 96 respectively, kindly lent by Lord Salisbury for the exhibition. They have been in use at Hatfield for over four years. The other relic shows a comparison between the methods of wiremen in the early days and now. One board is labelled "How not to do it," and is covered with specimens of excruciatingly bad joints of cables and wires, those actually used and cut out of installations of the date of 1880 or so. The other board, labelled "How to do it," shows, of course, the latest practice in beautifully neat joints. Various specimens of modern quick-break switches are shown as used by the firm in installations, such as for houses in Carlton House-terrace and various large country mansions, photographs of the interiors of these houses being also shown.

For country installations where wind or water power can be utilised, it is very necessary, of course, to regulate the resultant pressure from the dynamo in charging accumulators. Messrs. Laing, Wharton, and Down exhibit an apparatus which they term the "K" voltage regulator. A set of plate contacts leading to resistances dip into a vessel of mercury. The plates are of varying length, and the bar carrying them is raised or lowered by means of a solenoidal magnet actuated by the main current. The bar rises or falls as the speed and the pressure varies, cutting in or out the resistances. This simple arrangement is found to work admirably for speeds of the prime motor, varying from 800 up to 1,300 revolutions per minute. In the exhibit at the Palace this is shown connected to a motor, which drives a dynamo for supplying light to the tables and electroliers.

At the front of the stand, Messrs. Laing, Wharton, and Down show dynamos and motors in working. A 30-h.p. iron-clad motor is a very serviceable piece of machinery incapable of injury from ordinary accidents. It is interesting to remark that the external magnetic field of these machines is extremely low—hardly perceptible, in fact. Measurements have been recently taken of the external stray field of all the various types of dynamos in the Exhibition, and a paper is to be shortly read, we understand, before the Society of Arts upon this topic. The stray field from the iron-clad dynamos mentioned was found less than any other type tested; less, in fact, than seven C.G.S. units at 3in. from the machine, and, therefore, hardly perceptible, and certainly free from objection on account of injury to watches, besides being an additional cause of high efficiency. A combined shiplighting plant with the same type of machine is exhibited in action. The engine is a Robey vertical engine, specially adapted for electric light, coupled on the same bed plate to the dynamo. The size shown will supply 60 lamps of 16 c.p. run direct. Other sizes, of course, are made. A large four-pole iron-clad dynamo for 1,500 lights of 8 c.p. is also shown, driven by a motor by belting. The oiling arrangements in these are found to work with great satisfaction.



Laing, Wharton, and Down's Direct-Coupled Compound Engine and "Special" Dynamo, for 400 Lights.

Two loose rings of gunmetal are placed over grooves in the bearings, the whole being covered in by the metal casing, forming a box, which is partly filled with oil. The rotation of the rings keeps the lubrication automatically constant, and attention is only required once a week. Outside the Entertainment Court, but close by, is another and larger ship set of coupled engine and dynamo, with a 40-h.p. Robey compound engine, driving, at 300 revolutions, a dynamo for 400 lights of 8 c.p. This supplies some of the electroliers, and the fountain lights in the centre of the gallery, which we have already described in a previous number. It also drives the motors using the regulating apparatus, and the large dynamo which is used as a motor.

Laing, Wharton and Down's Artistic Fittings.

Altogether it must be acknowledged that Messrs. Laing, Wharton, and Down have a very interesting and comprehensive exhibit.

INSTITUTION OF CIVIL ENGINEERS.

At the ordinary meeting on Tuesday, the 10th of May, Mr. Berkley, president, being in the chair, the paper read was on "The Distribution and Measurement of Illumination," by Mr. Alex. P. Trotter, B.A., A.M.I.C.E.

This paper was divided into three sections. The first dealt with geometrical principles; the second with photometers; and the third with the results of measurements made in the streets and public buildings in London. When light falls upon a surface, that surface is said to be illuminated. Illumination consists of two factors—candle-power and distance. The carcel-meter was proposed in 1882 as a unit of illumination. Mr. Preece showed that this was equal to a standard candle at 12·7in., and proposed the name "Lux" for the English equivalent. The author has taken the candle-foot as a practical unit. The illumination of a horizontal plane at any point varies as the cube of the cosine of the angle of incidence of a ray of light falling on that point, when the candle-power and the height of the lamp are constant. Curves were given showing this distribution graphically; illumination being represented as ordinates, and distances from the source of light as abscissæ. The distribution of the total *light on a surface varies* as the solid angle subtended by that surface at the source of light. The usefulness of a white reflector depends on the solid angle which it subtends, and not upon its absolute dimensions. The resultant illumination, due to a number of lamps spaced at distances apart, equal to once, twice, three times, and six times their height from the ground, was shown by a number of curves. The distribution of the light of a continuous-current arc lamp is peculiar. For angles of incidence greater than 50deg. it varies as the fourth power of the cube of the cosine of the angle of incidence. Light falling in a more vertical direction is largely reduced by the shadow of the negative carbon.

The object of street lighting is twofold—to mark out the street with beacons, and to provide illumination. Illumination begins to be useful when it is comparable with moonlight. Moonlight in this country rarely exceeds one thirty sixth of a candle-foot, that is, a candle at 6ft.; it is generally between one-sixtieth to one-hundreth of a candle-foot. The distribution of illumination in more general cases was treated geometrically; the variation of illumination due to the varying height of a lamp was discussed, and it was shown that there was no particular virtue in the angle of incidence, the tangent of which is $\sqrt{2}$. Calculated contour curves of equal illumination due to two lights at a distance apart equal to three times their height, and to three lights arranged in a triangle, at a distance apart equal to one-and-a-half times their height, were given, together with curves of illumination due to arc lights spaced in a similar manner. The use of diagrams to which the author gave the name of characteristic curves was explained. In several respects these resembled steam-engine diagrams. The co-ordinates were candle-power and area; the area of the diagram was a measure of total light, or power in an optical form. The maximum and minimum illuminations in any example could be seen at a glance, and the shape of the curve showed the quality or regularity of the distribution. Characteristics for a square and for a circular area illuminated by a single light, and for several arrangements of uniformly spaced lights, were given.

The second section on photometry alluded to the different attempts which have been made to supplant photometers by thermopiles, radiometers, and photographic methods. The complication of gas-testing apparatus was contrasted with the simple forms of true photometers, such as those of Bunsen, Rumford, and Foucault. A photometer was described, in which a shadow was thrown by a mirror upon a screen and a reflected beam of light was superposed upon the shadow; the whole screen was of a uniform tone when a balance was effected. In a direct-reading photometer, a rod was placed nearly in the plane of the two lights to be compared. Two shadows were thrown on a screen, and the position at which the two shadows were of the same tone could be read off on a scale. The illumination photometers of Weber and Mascart were briefly described. Mr. Preece's photometer of 1883 depended on the measurement of the current of a small glow lamp. The sixth power of the current was approximately proportional to the candle-power. The current was adjusted by resistances. The details of this photometer were discussed, and Captain Abney's method of rapid oscillations in photometric measurement was described. Various errors were introduced in this use of a Bunsen screen and by the colour of the electric lamp at low candle-power. In a photometer designed by the author, in conjunction with Mr. Preece, in 1884, a glow lamp was made to approach or to recede from a Bunsen screen. The motion was given by a lever rolling on a cam in such a manner that the illumination could be read upon a uniformly divided scale. A number of modifications of this photometer were tried during the past winter, and resulted in the construction of an illumination photometer, with which a large number of measurements had been made. Two glow lamps, $\frac{3}{4}$ c.p. and $\frac{1}{4}$ c.p., were mounted in a long blackened box. Either or both could be used at once. Four lithanode cells supplied the current. A reflecting screen, covered with white paper, threw the light upwards through a star-shaped hole in a horizontal screen of cardboard. The reflecting screen was mounted on hinges and could be wound up by a fine chain, finally folding quite out of the light. The chain was wound upon a cam, and a hand or pointer was mounted on the axis of

this cam. The cam was so shaped that a nearly uniformly divided scale was obtained. The scale was graduated empirically. Readings were taken when the illumination of the horizontal cardboard screen appeared to be identical with the illumination of the movable reflecting screen, visible through the star-shaped hole. The range of this photometer is from 2·5 to·001 candle-feet.

Measurements were made in the South Kensington Museum, in which illumination of about half a candle-foot up to 3½ candle-feet were recorded. In Cannon-street Station the minimum was ·025 candle-foot, and the maximum ·4 candle-foot. In Charing Cross Station the minimum was ·05, and the maximum ·5. Several sets of measurements were made in the City. The result of systematic measurement of part of Queen Victoria-street was given in contour lines of equal illumination. The maximum in an exceptional case was 1·1, ordinary maximum ·3, minimum ·025. Contour lines were constructed from a considerable number of measurements in Whitehall. The illumination in Great George-street, Westminster, was also measured. The maximum was ·9, and the minimum ·005. The author was assisted in the street measurements by Mr. W. Winny and by Messrs. J. Leggat, L. E. Pierce, and W. O. Wallace, students at Finsbury Technical College. Characteristic curves were drawn from these observations, and enabled the degree and the quality of the lighting to be compared. The paper was accompanied by an appendix, containing tables of the value of a bougie-meter in candle-power at different distances, values of $\cos.^3 \theta$, and other powers of the cosine.

MR. PREECE ON THE ELECTRIC LIGHT.

Mr. W. H. Preece, F.R.S., read an interesting paper on Monday evening at the rooms of the Royal Institute of British Architects on "The Art of Internal Illumination of Buildings by Electricity." Mr. J. Macvicar Anderson, president of the institute, was in the chair.

Mr. Preece said that the art of the internal illumination of buildings was still in its infancy, and no one could predict what its future developments would be. Electricity was already rendering theatres bearable and houses healthier, while the architect was brought face to fact with a new art, in which the aid of the electrician was required to solve some of the difficulties that confronted him. History was silent as to the origin of tallow, pitch, wax, and oil, but gas as an illuminant came in, as they all knew, with the present century. From the earliest days history, whether culled from paintings or writings, informed us that lights had been but dim and crude until the middle of the present century. Light, by whatever means generated, followed the same laws, and was due to the rapid rhythmic undulations of the medium, called ether, which filled all space. Wherever there was light there was heat, and the hope of the philosopher to supply light without any heat at all was at present but a dream. Light could not be produced without heat, and the higher the temperature the brighter the light. Colour varied with the rate of vibration of the ether, while changes of colour were due to the changes of wave-motion of the ether. Light might indeed become so intense that all sense of colour was lost, and very bright illumination caused all colours to approach whiteness. If light emanated from a point, its intensity diminished in proportion with the square of the distance. The candle was taken in this country as the standard source of light, and the bright surface produced by it at a distance of 1ft. was the standard illumination by which to measure the amount of light distributed by any other means. This standard Mr. Preece called a "lux." The great problem for solution was so to diffuse light throughout a room that it should be distributed uniformly over the working surfaces with an intensity of a lux. Sixteen-candle glow lamps suspended 8ft. above the floor and fixed in 8ft. squares effected this purpose very efficiently, and groups of four such lamps fixed 16ft. high produced a similar result. The light a lamp gave was due to the expenditure of energy in its carbon filament; an electric current was driven through this filament by electric pressure, its resistance was overcome, it was intensely heated by the proceeding, and the result was pure unadulterated light. The energy expended per second by an ampere (the standard current), driven by a volt (the standard pressure) was called a watt. A 16-candle glow lamp took 64 watts, which, assuming the lamps to be fixed 8ft. high, meant that one watt per square foot of surface was required to secure ample illumination from lamps so fixed. Therefore, in designing the normal illumination of rooms, Mr. Preece took the floor area in square feet and divided it by 64, which gave the number of 16-c.p. lamps required, fixed 8ft. high, and these were increased or diminished according to the purposes of the room, its form and height, and other conditions. The adaptability of the eye to nearly every degree of light was very great, and it was almost impossible for it to judge accurately of the amount of light present. But it was not as a mere source of light that the glow lamp was superior to the gas burner. The former could be put anywhere and used without the adventitious aid of match or fire. It did not vitiate or unnecessarily warm the air, and it simplified the problem of ventilation, while at the same time it lent itself, above all, to the æsthetic harmony of furniture and decorations. Electric light was, however, not always absolutely safe; security was to be obtained only by good design, perfect materials, first-class workmanship, and rigid inspection. Imperfect materials erected by cheap contractors led to many disasters. On the other hand, it was stated that no fire had occurred in buildings fitted up under the rules and regulations, and inspected by the officers of the insurance companies in this country. In the lecturer's opinion everything ought, as much as possible, to be kept in view, and the conductors ought not to be hidden under wainscots or floors, or above ceilings. The glow lamp, excited by three watts per candle, was at present the most perfect source of domestic light, and when the patent expired, in a year or two, would be obtainable at one-third of the present price. It was scarcely fair to say all light should come from the side of a room, according to the taste of Lord Beaconsfield, as expressed in "Lothair," when describing the lighting of Belmont. The House of Commons was one of the best lighted chambers in London, and was lighted from the roof, a false glass ceiling excluding the heat and glare, and admitting only the light. What was wanted was to avoid the glare of the incandescent filament in the eyes, and to prevent the lamp from being too obtrusive; it could be shaded from the eye without its effectiveness being destroyed, and without the flow of light being obstructed or its quality being deteriorated. Judging from the Crystal Palace Exhibition, at which, however, several leading firms had not exhibited, Mr. Preece thought that the electric light fitter had not yet seized upon the spirit of the age—which was the rule of science over mere conventional ætheticism. Two exhibits at the Crystal Palace, however, especially deserved inspection. The one was a Tudor ribbed ceiling, erected by Messrs. Allen and Mannooch, who had applied glow lamps to the moulded intersecting pendants in such a way that the feeling of the artist was maintained by day, and was rather intensified, and not marred, by the artificial illuminant at night. The other was a bold attempt of Messrs Rashleigh Phipps and Dawson to design in ironwork the whole of the fittings of a dining-room, so that they should, in combination, convey an idea. The artist (Mr. Reynolds) had attempted to symbolise the solar system, the centre light over the table representing the sun, and the brackets on the walls the planets. A survey of the Royal Academy pictures, he thought, afforded instructive study. There were many interiors, but few into which artificial light had been introduced. Having described several pictures in which artificial light had been introduced with more or less successful results, Mr. Preece, in conclusion, expressed his belief that science was advancing with giant strides. Science had subdued nature so as to bring it within the compass of the human intellect, and art must follow the knowledge thus acquired. These two being the chief instruments of modern civilisation, the architect and engineer must work hand in hand.

A cordial vote of thanks was passed to Mr. Preece for his interesting paper, and a discussion followed.—*Times.*

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WORK IN VIEW.

There is no doubt but that the Crystal Palace Exhibition has given a fillip to work which has long been hatching, and hurried on schemes that were slumbering. Rumours are rife also that within the next few days another company will be launched for the purpose of carrying out the provisional orders of Islington and Camberwell. The company will have a capital of a quarter of a million, in five-pound shares. Reference to the legal proceedings which have just terminated will show that this proposed company has cleared its decks of "founders' shares." In the abstract, founders' shares may be made palatable, but in the majority of cases they are merely methods of putting the unearned increment into the pockets of harpies. Over and over again have we heard moneyed men decidedly refuse to invest one penny in companies where founders' shares appeared—and we think very wisely refused. A glance at the money columns of any financial paper will show that the quotations for founders' shares are out of all proportion to the quotations for ordinary shares. It is all very well to point out that ordinary shares participate in the profits up to a certain point before the founders' shares are allowed to participate, but after that, who gets the pull? Not the people who find the money, but the people who control what we have termed their unearned increment. We therefore congratulate the Islington and General Electric Supply Company (if that is to be their name) upon having rid themselves of all incubus. Before considering the prospects of such a company, it may be worth while to make an inference from the names of the directors, and the action with regard to founders' shares. The aim is evidently real sound work. The directors are men of keen business instincts and of great influence. This will be granted without demur if, as we expect, the board will include such names as Sir F. A. Abel, Ernest W. Barnard, Major-General Arthur Ellis, Sir F. Richard Pollock, and Mr. R. W. Wallace, aided in their sphere of operations by Messrs. Kapp, Kennedy, and Cooper. It would be difficult to name a stronger combination than this. No doubt, when the prospectus is issued, it will give the public an idea of the prospects of the company from the standpoint of a preliminary canvass of the district or districts in which it is proposed to erect stations. We are under an impression that Messrs. J. E. H. Gordon and Co. are the contractors to the company, and the public have an excellent opportunity of seeing an installation erected under their auspices at Sydenham-hill—a pretty complete description of which has appeared, with illustrations, in our columns. The experience with regard to central station work has for some years been accumulating, till at the present moment, notwithstanding all contention to the contrary, it may safely be predicted that properly designed, properly carried out, and in the right position, central station work will undoubtedly pay. The investment under these conditions is an exceedingly safe one. The consumption of electrical energy is and must be an increasing one. Every house built, every house

wired, means accelleration of development. Some shopkeepers may argue against the new illuminant, may fight against its introduction, but their efforts will be in vain. Let but one shop in a street install the light, and the others must gradually follow. Why? Not because the weekly, monthly, or quarterly bill will be less than the bill for gas, but because—and there is absolutely no doubt of this—the total management expenses will be less where the electric light is used than where gas is used. In many cases considerable sums will be saved by goods not being damaged, heat and noxious fumes will be absent, the health of the employés will be better, redecoration will be less frequent. More work will be done, and more easily done, in a given time with the one illuminant than with the other. All these and a hundred other cogent reasons can be urged in favour of electricity. But investors are not usually imbued with a wild desire to follow the impulse of reason; they ask, Has such a scheme been previously tried, and with what results? Well, scores of schemes have been tried, with all manner of results. The history of each scheme is necessary in order to understand the why of the result. It would be easy to tell the why of a failure, but the telling would land us in the law courts for libel. You must not tell the truth when somebody's pocket will suffer by it. Briefly, then, failure is too often writ because the principle adopted is "self" and "pelf," or, rather, "pelf for self." Take, however, an example where nothing of this kind can exist, and yet where a cheese-paring economy can hardly exist. We refer to Bradford. Here a central station, erected and equipped under the auspices of the Corporation, has, selling its energy at sixpence per unit, arrived at such a pitch of success that it has reduced the price to fivepence per unit. The Pall Mall Company, which has a concentrated area for working, but it is said not much more concentrated, if any, than Islington, may almost be termed a bonanza. The Kensington Company, working directly under the supervision of Mr. Crompton, gives an admirable example of how to do it. The prospects of the Westminster Company, again, may well be investigated. Mr. Wallace, one of the directors of the Islington Company, is similarly connected with Kensington and Westminster, and thus, if experience is worth aught, should be sufficiently experienced to guide the new company to success. We thus hope to chronicle within the next few days the launching of this company upon a sound basis, and the commencement of the work upon two or three more central stations within the metropolitan area. So much has been said about the forthcoming metropolitan work that at present we can do no more than direct attention to Dundee, Portsmouth, Hanley, Derby, Cheltenham, Dover, Canterbury, Nottingham, Hull, and a score or so of towns where electric lighting schemes are in a more or less advanced state of adoption.

MR. PREECE AT THE BRITISH ARCHITECTS.

The electrical industry owes much to Mr. Preece, who, perhaps more than any other individual, has expounded and popularised the information concerning electric lighting to public audiences. As we have pointed out many times, architects have, in the ordinary course of their profession, to adapt their designs to meet the progress of scientific applications. With the electric light a design may be more ornate, for it will be less liable to deteriorate. The materials, too, used with the electric light may differ considerably from those which would be applicable if gas or any other artificial illuminant were used. The architect, again, in his design has considerable power in so arranging his materials as to facilitate the safe wiring of buildings. It is, therefore, of considerable importance that architects should be, as far as possible, educated as to the capabilities of the electric light. Mr. Preece has done much in this direction, and his latest paper dwells particularly upon what may be termed the physical properties of the electric light and its illuminating power, as well as upon its applicability to decorative purposes, and the means whereby it could be made an extremely safe illuminant. The full text of this lecture will, we understand, be given in the society's *Transactions*; meanwhile an excellent abstract was given in the *Times* of May 18, which we produce elsewhere.

DINNER TO PROF. AYRTON.

On Friday evening last a complimentary dinner was given to Prof. Ayrton, F.R.S., at the Holborn Restaurant by 21 of his former students, who are now well known in the electrical profession. Mr. W. B. Esson occupied the chair, and amongst the guests present were Mr. W. H. Preece, F.R.S., Prof. Thompson, F.R.S., Prof. Perry, F.R.S., Mr. F. H. Webb, and Mr. James Swinburne.

After partaking of an excellent dinner, and when the toast of "The Queen" had been honoured, Mr. ALBION T. SNELL proposed "The Colleges of the City and Guilds of London Institute," coupling with the toast the names of Profs. Thompson and Perry, both of whom replied in suitable terms. Prof. Thompson was, he said, carrying on the work at Finsbury which Prof. Ayrton had so well begun before his advent, while Prof. Perry claimed to be a student of Prof. Ayrton just as much as any of the subscribers present, inasmuch as he had been a deal of trouble to him (Prof. Ayrton) and had been well instructed and well bullied by him into the bargain.

The CHAIRMAN (Mr. W. B. Esson) next rose to propose the toast of the evening, "The health of Prof. Ayrton." He observed that in their student days most of them had likely been toasted by the professor in a somewhat different way. However, the position was now reversed, as they were that night toasting the professor. After referring to the progress made in recent years, both in electric lighting and electric transmission of power, he said that all along the plane of development in both branches could be traced the name of Ayrton, and pointed out that notwithstanding the number and value of the professor's contributions to electrical engineering, his researches in the domain of physics had not been less valuable or less appreciated. This had been recognised by his election as a fellow of the Royal Society and as president of the Physical Society. But he was also president of the Institution of Electrical Engineers, and so combined the theoretical with the practical. He was not content with high and dry physics, but remained always in touch with the world of practice, where his career began. That was the real secret of Prof. Ayrton's success as a teacher of technology, and while professors of academic seats of learning might believe that the function of a university was to teach useless knowledge, Prof. Ayrton believed that, at any rate, the function of the

technical college was to teach the knowledge of most worth, and which would best enable a man to cut his way in the world. After referring to the evanescent character of dinners, he observed that his past students did not wish Prof. Ayrton to forget all about their pleasant party, so they had put the expression of their regards into a more tangible and permanent form by getting it put in black and white. Mr. Esson then, in the name of the students, handed to Prof. Ayrton an illuminated testimonial, framed in gilt oak, and bearing the names of Messrs. L. B. Atkinson, Frank Bailey, H. J. Dowsing, W. B. Esson, W. Geipel, Reg. J. Jones, W. M. Mordey, Fras. Mudford, Frank Nalder, I. Probert, A. Reckenzaun, F. M. Rogers, Henry M. Sayers, W. B. Sayers, R. Percy Sellon, A. T. Snell, W. E. Sumpner, Ernest B. Vignoles, R. Mullineux Walmsley, H. D. Wilkinson, and Arthur Wright. He asked them to drink to the professor's long life, perfect health, and full success.

Prof. AYRTON, in responding, said he felt deeply grateful for the very kind and appreciative way in which his labours had been referred to, and thanked them most sincerely for the testimonial they had kindly presented to him. He next dwelt upon the rapid advance made in recent years in popular views on technical education, an advance our forefathers never dreamed of. The London County Council voted £30,000 per annum for the teaching of science and industry, but there was something like a million pounds still available, if a band of idealists were to come forward and endeavour to secure a portion of this princely sum. Prof. Ayrton advocated the establishment of a great laboratory of physical research, where all who entered would be students in the highest sense of the word. There would be no examinations, but all would work for the general advancement of knowledge for the good of the community. In conclusion, he alluded in praiseworthy terms to his assistant and associate, Mr. Mather.

Mr. ATKINSON then proposed the toast of "The Institution of Electrical Engineers," to which Mr. F. H. WEBB, the secretary, replied. Mr. REG. J. JONES next proposed "The Health of the Absentees," who, due to distance or to pressing business engagements, were prevented from attending. Amonst these were Mr. H. M. Sayers, in Oporto; Mr. W. B. Sayers, in Glasgow; Prof. Walmsley, in Edinburgh; and Messrs. Mordey, Mudford, Dowsing, Rogers, Bailey, and Probert, who at the last moment had found themselves unable to attend.

"Our Guests" was then proposed by Mr. R. PERCY SELLON, to which Mr. PREECE replied, and a vote of thanks to the Chairman, proposed by Mr. SWINBURNE, brought the pleasant proceedings to a termination.

Between the speeches songs were given by Mr. Trefelyn David, violin solos by Mr. Jacobi, and piano solos by Mr. W. Emerson, all of which were much appreciated.

BRADLEY'S MULTIPHASE PATENTS.

It is not our province to determine the priority of patent rights, but besides Tesla, Mr. C. S. Bradley was also in the field in 1888. This will be seen from his patent specification of August 20, 1889, the important part of the text of which is given herewith. We have not reproduced Figs. 1 to 7, as these are diagrammatic, and the principle of the application is easily seen in the remaining figures, which are numbered as in the specification.

In the generation, distribution, and utilisation of alternating currents it has been proposed to use two sets of coils on the generator, arranged angularly at 90deg., supplying two circuits with currents whose time-periods differed by one quarter-phase, and these two currents or sets of current were utilised to operate an electric motor having corresponding circuits symmetrically arranged, so that the alternation of the wave-lengths or vibrations of current produced a rotation of the poles of the motor armature, and the armature revolved in consequence. Such a system is clearly set forth in Letters Patent No. 390,439, issued to me October 2, 1888. I have therein shown a generator and a motor, both having the armature circuit closed, and simply tapped at four points, 90deg. apart, each two opposite points being connected into one external circuit, and the other two opposite points being connected into the other external circuit. The external circuits obviously could be so arranged that one wire would serve as a common return for both. I have discovered, however, that the rotation of polarity in the motor can be accomplished without having as many as four coils, or two pairs of coils symmetrically arranged, and the object of my present invention is to reduce the elements to the smallest possible number with respect to both the generator and the motor.

The present invention consists in a dynamo-electric machine (whether generator or motor) having a closed armature circuit tapped at three points, each of which is connected to one of three contact rings, such armature revolving in inductive proximity to a field magnet.

The invention further consists in a dynamo-electric machine constructed and adapted to generate or absorb three currents or waves of current all differing in their time-periods.

The invention further consists in a dynamo-electric machine constructed and adapted to generate or absorb three currents or waves of current, each one-third of a phase or wave-length behind its predecessor.

The invention further consists in the combination and arrangement of devices, all substantially as hereinafter fully described and claimed.

In alternating-current generators the number of field-magnet poles determines the number of vibrations per revolution, and for the sake of simplifying the description I will show the invention as applied to a two-pole machine, though, of course, it can be applied to other forms.

In the drawings which form part of this specification, Figs. 1 to 6 inclusive, show diagrammatically the generator in six equal and successive portions of one revolution. Figs. 1A to 6A, inclusive, show the corresponding phases produced in the external circuits. Fig. 7 is a completed diagram of the phases occurring during the one revolution. Fig. 8 is a simple diagram representing my invention applied to a two-pole machine. Fig. 9 is a diagram showing the construction of the generator when intended for self-excitation. Fig. 10 is a diagram representing the manner of connecting a closed-circuit armature to give three series of alternating currents and three external circuits adapted to utilise them separately. Fig. 11 is a diagram showing a generator and motor, both self-excited, and the connecting circuits.

Referring to Figs. 8, 9, and 10, it will be seen that I can use a simple ring armature, A, with continuous wiring closed on itself, the armature being placed for revolution in the field, N S, which may be excited by the rectified current of the armature or a shunt thereof, or by a separate exciter, or by any of the usual or known methods. I select three equidistant points, *a*, *b*, and *c*, of the armature winding and connect them to the contact rings, *d*, *e*, *f*, which are shown as fitted against the end of the armature, but will in practice be on the shaft, as in Fig. 11. Separate brushes, *g*, *h*, *i*, bear on the rings, and, being three in number, are capable of forming three distinct pairs of circuits for external distribution with only three wires.

By reference to the operation disclosed in Figs. 1 to 6 and 1A to 6A, inclusive, and Fig. 10, the peculiar action of the generator will be understood. The diagrams, Figs. 1A to 6A, show the three partial phases produced during the sixth of a revolution of the armature which each diagram represents. If we now consider (see Fig. 10) each of the brushes, *g*, *h*, *i*, connected to one wire of a three-wire external circuit, *k*, *l*, *m*, it will be seen that the latter may form three pairs, *k l*, *k m*, and *l m*, and in each pair consumption or translating devices—for example, lamps, *n*—may be connected. Upon now tracing the diagrams in connection with Fig. 10, it will be seen that each of the three external circuits will be a path for a distinct series of alternations. The three sections of the armature, A, will deliver, respectively, the alternations or waves of current indicated on the diagrams by *a b*, *a c*, and *b c*, and each set of waves will be complete and continuous, but will be behind one another in their time-periods to the extent of one-third of a phase or wave-length. If, then, the three external circuits be closed, each will receive a single set of alternations and serve for lighting and other distribution purposes, and the current strengths will depend upon the resistances in the circuits.

In my said former patent I have shown that an alternating-current generator with two pairs of collecting devices 90deg. apart greatly increase the output capacity of a given machine owing to the quarter-phase difference between the alternations. In the present case, with only three collecting devices, the output capacity is still more increased by reason of the alternations differing by a third of a wave-length. Obviously, instead of the lamps, *n*, in Fig. 10, I can substitute the primary coils of converters, *p*, and place the lamps or other consumption devices in the secondary circuits of the converters, as indicated also in the same figure.

As in my patent, No. 390,439, it is evident that when two such machines are connected together, as shown in Fig. 11, whether their field magnets be energised by rectified currents or otherwise, the first being power-driven, the second machine will operate as a motor in a manner, so far as rotation is concerned, similar to the rotation of the motor set forth in my said patent. I have shown the generator, G, and motor, M, as

substantially alike, and each with a rectifying commutator for delivering direct current to the field magnets similarly to the plan illustrated by the diagram, Fig. 9. The three connecting circuits will in this case, as in Fig. 10, constitute three different circuits, and will be delivered into the motor armature in such manner as to throw into the same in succession three separate series of current alternations, each of which will be substantially one-third of a wave-length behind the series preceding it, and will therefore determine the rotation of the armature, as described in my former patent.

I have discovered in electric motors operated upon the principle of two or more alternating currents differing in phase—such, for instance, as that shown in my said former patent or that shown in Fig. 9—that when the current is admitted to the armature of the motor it is difficult to start the latter when the field-magnet circuit is closed, whether the latter be supplied with its exciting current from the mains or from an independent source; but if at the moment of introduction of current into the armature circuit the circuit of the field magnet be left open,

delivered to the brushes, g, h, i, which bear on the contact-rings, d, e, f, and thence to the desired consumption devices.

By the foregoing invention I obtain the best possible results from an alternating-current machine with the least possible number of distributing or supply wires. This is due to the two features of closed armature circuit and trisected winding. The latter determines the one-third phase difference in the series of alternations or waves, and the former permits three separate external circuits to be established on only three wires, while the potential of all three will be substantially alike. Were the armature circuit made up of three separate coils, six wires would be required in the external circuits to accomplish the same results. Were the armature circuit quadrisected, as in my previous patent, two separate circuits can be established with three wires, one being a common return for the other two; but only two independent currents can then be generated, each supplementing the other. It is true that with the quadrisected armature two currents are obtainable, each of which may be practically as great in strength as the machine

Fig. 8

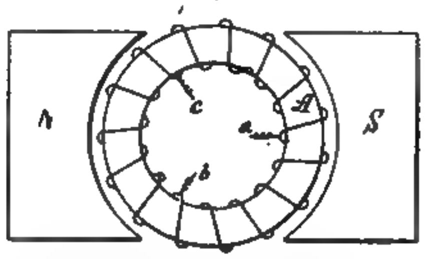


Fig. 9

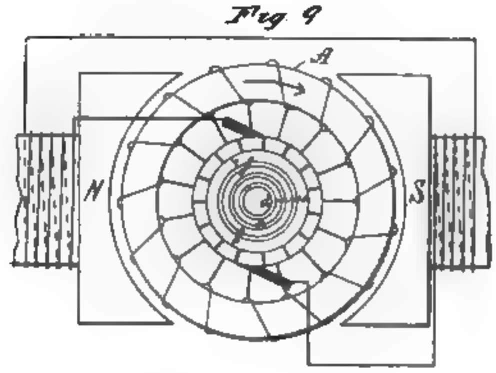


Fig. 10

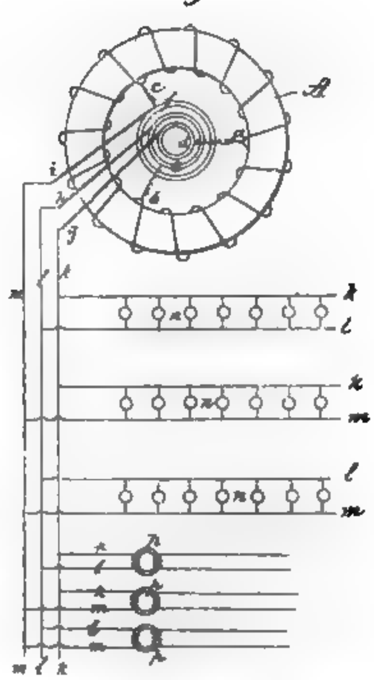
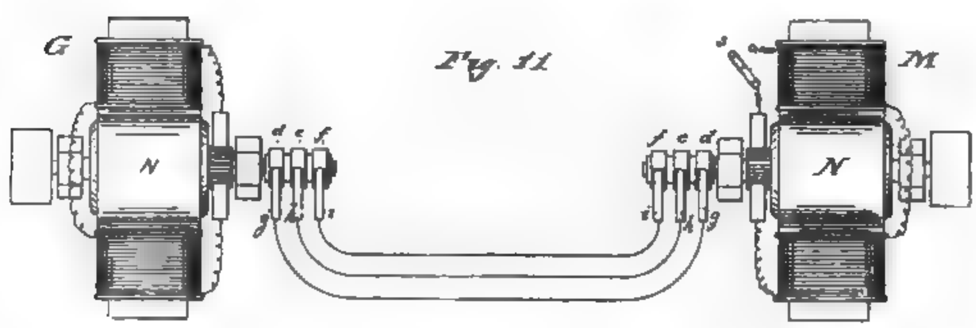


Fig. 11



the armature will readily start into rotation and quickly rise in speed until it synchronises with the generator, and the field-magnet circuit can then be closed and the operation of the armature will continue under its best conditions and remain at the speed of the generator.

In Fig. 11 I have shown the field magnet of the motor as being excited by the currents from the main circuits rectified by a commutator, and in this field-magnet circuit I locate a switch, s, for the above purpose.

Obviously, electromotive devices similar to the motor shown in Fig. 11 may be inserted in the circuits, k, l, m, and the entire current can be rectified by means of the armature, A, and its commutator and brushes, from the latter of which the rectified and continuous current may be delivered to any desired translating or consumption device—such, for instance, as a continuous-current motor, an electroplating bath, an arc lamp, or other device adapted to use with a continuous current. It is also obvious, as set forth in my above-mentioned patent, that continuous currents delivered to such an electromotive device and passing in at the commutator brushes can be split into three series of alternating currents of differing phase and

would stand if produced in the ordinary way; but it is also true that with my present trisected armature three currents are obtainable, each of which may be practically as great in strength as the machine could generate with a four-coil or quadrisected armature, and this I accomplish with three separate external circuits composed altogether of but three wires. This I hold to be the maximum result with the fewest components of external circuit.

In the claims I use the term "current-leading device" as expressive of the means of connecting the machine to the external circuit, whether such means be rings and brushes or commutator and brushes, or both, or simple fixed connections. The last would obviously be sufficient, in case I reversed the arrangement of the machine, making the armature stationary and the field magnet movable. I claim as my invention—

1. The combination, with an alternating-current dynamo-electric machine adapted to generate and deliver three separate series of alternations differing in their time-periods by one-third of a phase, of three external circuits composed in all of three conductors permutated into said three circuits, and consumption devices located in said external circuits.

2. In an electromotive device, the combination of a field magnet and a rotating armature provided with a current-rectifying commutator and brushes therefor, through which current is received into the armature and rotation produced in the moving part of the machine, three current-leading devices on the one hand connected, respectively, into the armature circuit at equidistant points and so arranged relatively as to lead off three independent series of alternating currents substantially one-third of a phase apart in their relative time-periods, and on the other hand connected with three external circuits composed in all of three conductors permutated into the said three circuits, and consumption devices located in each of the three circuits.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 471.)

This idea is not novel. Men have been led to it long ago by instinct or reason. It has been expressed in many ways, and in many places, in the history of old and new. We find it in the delightful myth of Antheus, who derives power from the earth; we find it among the subtle speculations of one of your splendid mathematicians, and in many hints and statements of thinkers of the present time. Throughout space there is energy. Is this energy static or kinetic? If static, our hopes are in vain; if kinetic—and this we know it is for certain—then it is a mere question of time when men will succeed in attaching their machinery to the very wheelwork of nature. Of all, living or dead, Crookes came nearest to doing it. His radiometer will turn in the light of day and in the darkness of the night; it will turn everywhere where there is heat, and heat is everywhere. But, unfortunately, this beautiful little machine, while it goes down to posterity as the most interesting, must likewise be put on record as the most inefficient machine ever invented!

The preceding experiment is only one of many equally interesting experiments which may be performed by the use of only one wire with alternate currents of high potential and frequency. We may connect an insulated line to a source of such currents, we may pass an inappreciable current over the line, and on any point of the same we are able to obtain a heavy current, capable of fusing a thick copper wire. Or we may, by the help of some artifice, decompose a solution in an electrolytic cell by connecting only one pole of the cell to the line or source of energy. Or we may, by attaching to the line, or only bringing into its vicinity, light up an incandescent lamp, an exhausted tube, or a phosphorescent bulb. However impracticable this plan of working may appear in many cases, it certainly seems practicable, and even recommendable, in the production of light. A perfected lamp would require but little energy, and if wires are used at all, we ought to be able to supply that energy without a return wire. It is now a fact that a body may be rendered incandescent or phosphorescent by bringing it either in single contact or merely in the vicinity of a source of electric impulses of the proper character, and that in this manner a quantity of light sufficient to afford a practical illuminant may be produced. It is, therefore, to say the least, worth while to attempt to determine the best conditions and to invent the best appliances for attaining this object. Some experiences have already been gained in this direction, and I will dwell on them briefly, in the hope that they might prove useful. The heating of a conducting body enclosed in a bulb, and connected to a source of rapidly-alternating electric impulses, is dependent on so many things of a different nature, that it would be difficult to give a generally applicable rule under which the maximum heating occurs. As regards the size of the vessel, I have lately found that at ordinary or only slightly differing atmospheric pressures, when air is a good insulator, and hence practically the same amount of energy by a certain potential and frequency is given off from the body, whether the bulb be small or large, the body is brought to a higher temperature if enclosed in a small bulb, because of the better confinement of heat in this case. At lower pressures, when air becomes more or less conducting, or if the air be sufficiently warmed as to become conducting, the body is rendered more intensely incandescent in a large bulb, obviously because, under otherwise equal conditions of tests, more energy may be given off from the body when the bulb is large. At very high degrees of exhaustion, when the matter in the bulb becomes "radiant," a large bulb has still an advantage, but a comparatively slight one, over the small bulb. Finally, at excessively high degrees of exhaustion, which cannot be reached except by the employment of special means, there seems to be, beyond a certain and rather small size of vessel, no perceptible difference in the heating.

These observations were the result of a number of experiments, of which one, showing the effect of the size of the bulb at a high degree of exhaustion, may be described and shown here, as it presents a feature of interest. Three spherical bulbs of 2in., 3in., and 4in. diameter were taken, and in the centre of each was mounted an equal length of an ordinary incandescent lamp filament of uniform thickness. In each bulb the piece of filament was fastened to the leading-in wire of platinum, contained in a glass stem sealed in the bulb; care being taken, of course, to make everything as nearly alike as possible. On each glass stem in the inside of the bulb was slipped a highly-polished tube made of aluminium sheet, which fitted the stem and was held on it by spring pressure. The function of this aluminium tube will be explained subsequently. In each bulb an equal length of filament protruded above the metal tube. It is sufficient to say now that under these conditions equal lengths of filament of the same thickness—in other words, bodies of equal bulk—were brought to incandescence. The three bulbs were sealed to a glass tube, which was connected to a Sprengel pump. When a high vacuum had been reached, the glass tube carrying the bulbs was sealed off. A current was then turned on successively on each bulb, and it was found that the filaments came to about the same brightness, and, if anything, the smallest bulb, which was placed midway between the two larger ones, may have been slightly brighter. This result was expected, for when either of the bulbs was connected to the coil luminosity spread through the other two, hence the three bulbs constituted really one vessel. When all the three bulbs were connected in multiple arc to the coil, in the largest of them the filament glowed brightest, in the next smaller it was a little less bright, and in the smallest it only came to redness. The bulbs were then sealed off and separately tried. The brightness of the filaments was now such as would have been expected on the supposition that the energy given off was proportionate to the surface of the bulb, this surface in each case representing one of the coatings of a condenser. Accordingly, there was less difference between the largest and the middle-sized than between the latter and the smallest bulb.

An interesting observation was made in this experiment. The three bulbs were suspended from a straight bare wire connected to a terminal of the coil, the largest bulb being placed at the end of the wire, at some distance from it the smallest bulb, and an equal distance from the latter the middle-sized one. The carbons glowed then in both the larger bulbs about as expected, but the smallest did not get its share by far. This observation led me to exchange the positions of the bulbs, and I then observed that whichever of the bulbs was in the middle it was by far less bright than it was in any other position. This mystifying result was, of course, found to be due to electrostatic action between the bulbs. When they were placed at considerable distance, or when they were attached to the corners of an equilateral triangle of copper wire, they glowed about in the order determined by their surfaces. As to the shape of the vessel, it is also of some importance, especially at high degrees of exhaustion. Of all the possible constructions, it seems that a spherical globe with the refractory body mounted in its centre is the best to employ. In experience it has been demonstrated that in such a globe a refractory body of a given bulk is more easily brought to incandescence than when otherwise shaped bulbs are used. There is also an advantage in giving to the incandescent body the shape of a sphere, for self evident reasons. In any case the body should be mounted in the centre, where the atoms rebounding from the glass collide. This object is best attained in the spherical bulb, but it is also attained in a cylindrical vessel with one or two straight filaments coinciding with its axis, and possibly also in parabolical or spherical bulbs with the refractory body or bodies placed in the focus or foci of the same, though the latter is not probable, as the electrified atoms should in all cases rebound normally from the surface they strike, unless the speed were excessive, in which case they would probably follow the general law of reflection. No matter what shape the vessel may have, if the exhaustion be low, a filament mounted in the globe is brought to the same degree of incandescence in all parts; but if the exhaustion be high, and the bulb be spherical or pear-shaped, as usual, focal points form, and the filament is heated to a higher degree at or near such points. To illustrate the effect, I have here two small bulbs which are alike, only one is exhausted to a low and the other to a very high degree. When connected to the coil, the filament in the former glows uniformly throughout all its length; whereas in the latter, that portion of the filament which is in the centre of the bulb glows far more intensely than the rest. A curious point is that the phenomenon occurs even if two filaments are mounted in a bulb, each being connected to one terminal of the coil, and, what is still more curious, if they be very near together, provided the vacuum be very high. I noted in experiments with such bulbs that the filaments would give way usually at a certain point, and in the first trials I attributed it to a defect in the carbon. But when the phenomenon occurred many times in succession I recognised its real cause.

In order to bring a refractory body enclosed in a bulb to incandescence, it is desirable, on account of economy, that all the energy supplied to the bulb from the source should reach without loss the body to be heated; from there, and from nowhere else, it should be radiated. It is, of course, out of the question to reach this theoretical result, but it is possible by a proper construction of the illuminating device to approximate more or less to it. For many reasons, the refractory body is placed in the centre of the bulb, and it is usually supported on a glass stem containing the leading-in wire. As the potential of this wire is alternated, the rarefied gas surrounding the stem is acted upon inductively, and the glass stem is violently bombarded and heated. In this manner by far the greater portion of the energy supplied to the bulb—especially when exceedingly high frequencies are used—may be lost for the purpose contemplated. To obviate this loss, or at least to reduce it to a minimum, I usually screen the rarefied gas surrounding the stem from the inductive action of the leading-in wire by providing the stem with a tube or coating of conducting

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

material. It seems beyond doubt that the best among metals to employ for this purpose is aluminium, on account of its many remarkable properties. Its only fault is that it is easily fusible, and therefore its distance from the incandescing body should be properly estimated. Usually, a thin tube, of a diameter somewhat smaller than that of the glass stem, is made of the finest aluminium sheet, and slipped on the stem. The tube is conveniently prepared by wrapping around a rod fastened in a lathe a piece of aluminium sheet of the proper size, grasping the sheet firmly with clean chamois leather or blotting-paper, and spinning the rod very fast. The sheet is wound tightly around the rod, and a highly-polished tube of two or three layers of the sheet is obtained. When slipped on the stem, the pressure is generally sufficient to prevent it from slipping off, but, for safety, the lower edge of the sheet may be turned inside. The upper inside corner of the sheet—that is, the one which is nearest to the refractory incandescent body—should be cut out diagonally, as it often happens that, in consequence of the intense heat, this corner turns towards the inside and comes very near to, or in contact with, the wire, or filament, supporting the refractory body. The greater part of the energy supplied to the bulb is then used up in heating the metal tube, and the bulb is rendered useless for the purpose. The aluminium sheet should project above the glass stem more or less—1in. or so—or else, if the glass be too close to the incandescing body, it may be strongly heated, and become more or less conducting, whereupon it may be ruptured, or may, by its conductivity, establish a good electrical connection between the metal tube and the leading-in wire, in which case, of course, again, most of the energy will be lost in heating the former. Perhaps the best way is to make the top of the glass tube, for about an inch, of a much smaller diameter. To still further reduce the danger arising from the heating of the glass stem, and also with the view of preventing an electrical connection between the metal tube and the electrode, I preferably wrap the stem with several layers of thin mica, which extends at least as far as the metal tube. In some bulbs I have also used an outside insulating cover.

The preceding remarks are only made to aid the experimenter in the first trials, for the difficulties which he encounters he may soon find means to overcome in his own way. To illustrate the effect of the screen, and the advantage of using it, I have here two bulbs of the same size, with their stems, leading-in wires, and incandescent lamp filaments tied to the latter, as nearly alike as possible. The stem of one bulb is provided with an aluminium tube, the stem of the other has none. Originally the two bulbs were joined by a tube which was connected to a Sprengel pump. When a high vacuum had been reached, first the connecting tube and then the bulbs were sealed off; they are therefore of the same degree of exhaustion. When they are separately connected to the coil giving a certain potential, the carbon filament in the bulb provided with the aluminium screen is rendered highly incandescent, while the filament in the other bulb may, with the same potential, not even come to redness, although in reality the latter bulb takes generally more energy than the former. When they are both connected together to the terminal, the difference is even more apparent, showing the importance of the screening. The metal tube placed on the stem containing the leading-in wire performs really two distinct functions: First, it acts more or less as an electrostatic screen, thus economising the energy supplied to the bulb; and, second, to whatever extent it may fail to act electrostatically, it acts mechanically, preventing the bombardment, and consequently intense heating and possible deterioration, of the slender support of the refractory incandescent body, or of the glass stem containing the leading-in wire. I say slender support, for it is evident that in order to confine the heat more completely to the incandescing body its support should be very thin, so as to carry away the smallest possible amount of heat by conduction. Of all the supports used I have found an ordinary incandescent lamp filament to be the best, principally because, among conductors, it can withstand the highest degrees of heat.

The effectiveness of the metal tube as an electrostatic screen depends largely on the degree of exhaustion. At excessively high degrees of exhaustion—which are reached by using great care and special means in connection with the Sprengel pump—when the matter in the globe is in the ultra-radiant state, it acts most perfectly. The shadow of the upper edge of the tube is then sharply defined upon the bulb. At a somewhat lower degree of exhaustion, which is about the ordinary "non-striking" vacuum, and generally as long as the matter moves predominantly in straight lines, the screen still does well. In elucidation of the preceding remark it is necessary to state what is a "non-striking" vacuum for a coil operated, as ordinarily, by impulses, or currents, of low frequency is not, by far, so when the coil is operated by currents of very high frequency. In such case the discharge may pass with great freedom through the rarefied gas through which a low-frequency discharge may not pass, even though the potential be much higher. At ordinary atmospheric pressures just the reverse rule holds good; the higher the frequency, the less the spark discharge is able to jump between the terminals, especially if they are knobs or spheres of some size. Finally, at very low degrees of exhaustion, when the gas is well conducting, the metal tube not only does not act as an electrostatic screen, but even is a drawback, aiding to a considerable extent the dissipation of the energy laterally from the leading-in wire. This, of course, is to be expected. In this case—namely, the metal tube is in good electrical connection with the leading-in wire, and most of the bombardment is directed upon the tube. As long as the electrical connection is not good, the conducting tube is always of some advantage, for although it may not greatly economise energy, still it protects the support of the refractory button, and is a means for concentrating more energy upon the same.

To whatever extent the aluminum tube performs the function of a screen, its usefulness is therefore limited to very high degrees of exhaustion when it is insulated from the electrode—that is, when the gas as a whole is non-conducting, and the molecules, or atoms, act as independent carriers of electric charges. In addition to acting as a more or less effective screen, in the true meaning of the word, the conducting tube or coating may also act, by reason of its conductivity, as a sort of equaliser or dampener of the bombardment against the stem. To be explicit, I assume the action as follows: Suppose a rhythmical bombardment to occur against the conducting tube by reason of its imperfect action as a screen, it certainly must happen that some molecules, or atoms, strike the tube sooner than others. Those which come first in contact with it give up their superfluous charge, and the tube is electrified, the electrification instantly spreading over its surface. But this must diminish the energy lost in the bombardment, for two reasons: firstly, the charge given up by the atoms spreads over a great area, and hence the electric density at any point is small, and the atoms are repelled with less energy than they would be if they would strike against a good insulator; secondly, as the tube is electrified by the atoms which first come in contact with it, the progress of the following atoms against the tube is more or less checked by the repulsion which the electrified tube must exert upon the similarly electrified atoms. This repulsion may perhaps be sufficient to prevent a large portion of the atoms from striking the tube, but at any rate it must diminish the energy of their impact. It is clear that when the exhaustion is very low, and the rarefied gas well conducting, neither of the above effects can occur, and, on the other hand, the fewer the atoms, with the greater freedom they move; in other words, the higher the degree of exhaustion, up to a limit, the more telling will be both the effects.

FIG. 18.—Bulb with Mica Tube with Aluminium Screen.

What I have just said may afford an explanation of the phenomenon observed by Prof. Crookes—namely, that a discharge through a bulb is established with much greater facility when an insulator than when a conductor is present in the same. In my opinion, the conductor acts as a dampener of the motion of the atoms in two ways pointed out; hence, to cause a visible discharge to pass through the bulb, a much higher potential is needed if a conductor, especially of much surface, be present. For the sake of clearness of some of the remarks before made, I must now refer to Figs. 18, 19, and 20, which illustrate various arrangements with a type or bulb most generally used. Fig. 18 is a section through a spherical bulb, L, with the glass stem, *s*, containing the leading-in wire, *w*, which has a lamp filament, *l*, fastened to it, serving to support the refractory button, *m*, in the centre. M is a sheet of thin mica wound in several layers around stem, *s*, and *a* is the aluminium tube. Fig. 19 illustrates such a bulb in a somewhat more advanced stage of perfection. A metallic tube, S, is fastened by means of some cement to the neck of the tube. In the tube is screwed a plug, P, of insulating material, in the centre of which is fastened a metallic terminal, *t*, for the connection to the leading-in wire, *w*. This terminal must be well insulated from the metal tube, S, therefore, if the cement used is conducting—and most generally it is sufficiently so—the space between the plug, P, and the neck of the bulb should be filled with some good insulating material, as mica powder. Fig. 20 shows a bulb made for experimental purposes. In this bulb the aluminium tube is provided with an external connection, which serves to investigate the effect of the tube under various conditions. It is referred to chiefly to suggest a line of experiment followed.

Since the bombardment against the stem containing the leading-in wire is due to the inductive action of the latter upon the rarefied gas, it is of advantage to reduce this action as far as practicable by employing a very thin wire, surrounded by a very thick insulation of glass or other material, and by making the wire passing through the rarefied gas as short as practicable. To combine these features I employ a large tube, T (Fig. 21), which protrudes into the bulb to some distance, and carries on the top a very short

glass stem, *s*, into which is sealed the leading-in wire, *w*, and I protect the top of the glass stem against the heat by a small aluminium tube, *a*, and a layer of mica underneath the same, as usual. The wire, *w*, passing through the large tube to the outside of the bulb, should be well insulated—with a glass tube, for instance—and the space between ought to be filled out with some excellent insulator. Among many insulating powders I have tried, I have found that mica powder is the best to employ. If this precaution is not taken, the tube, T, protruding into the bulb will surely be cracked in consequence of the heating by the brushes, which are apt to form in the upper part of the tube, near the exhausted

FIG. 19.—Improved Bulb with Socket and Screen.

globe, especially if the vacuum be excellent, and therefore the potential necessary to operate the lamp very high. Fig. 22 illustrates a similar arrangement, with a large tube, T, protruding into the part of the bulb containing the refractory button, *m*. In this case the wire leading from the outside into the bulb is omitted, the energy required being supplied through condenser coatings, C C. The insulating packing, P, should in this construction be tightly fitting to the glass, and rather wide, or otherwise the discharge might avoid passing through the wire, *w*, which connects the inside condenser coating to the incandescent button, *m*.

The molecular bombardment against the glass stem in the bulb is a source of great trouble. As illustration I will cite a phenomenon only too frequently and unwillingly observed. A bulb, preferably a large one, may be taken, and a good conducting body, such as a piece of carbon, may be mounted in it upon a platinum wire sealed in the glass stem. The bulb may be exhausted to a fairly high degree, nearly to the point when phosphorescence begins to appear. When the bulb is connected with the coil, the piece of

FIG. 20.—Bulb for Experiments with Conducting Tube.

carbon, if small, may become highly incandescent at first, but its brightness immediately diminishes, and then the discharge may break through the glass somewhere in the middle of the stem, in the form of bright sparks, in spite of the fact that the platinum wire is in good electrical connection with the rarefied gas through the piece of carbon or metal at the top. The first sparks are singularly bright, recalling those drawn from a clear surface of mercury. But as they heat the glass rapidly they of course lose their brightness, and cease when the glass at the ruptured place becomes incandescent, or generally sufficiently hot to conduct. When observed for the first time the phenomenon must appear very curious, and shows in a striking manner how radically different alternate currents, or impulses, of high frequency behave, as compared with steady currents, or currents of low frequency. With such currents—namely, the latter—the phenomenon would, of course, not occur. When frequencies such as are obtained by mechanical means are used, I think that the rupture of the glass is more or less the consequence of the bombardment, which warms it up and impairs its insulating power; but with frequencies obtainable with condensers, I have no doubt that the glass may give way without previous heating.

FIG. 21.—Improved Bulb with Non-conducting Button.

Although this appears most singular at first, it is in reality what we might expect to occur. The energy supplied to the wire leading into the bulb is given off partly by direct action through the carbon button, and partly by inductive action through the glass surrounding the wire. The case is thus analogous to that in which a condenser shunted by a conductor of low resistance is connected to a source of alternating currents. As long as the frequencies are low, the conductor gets the most, and the condenser is perfectly safe; but when the frequency becomes excessive the *rôle* of the conductor may become quite insignificant. In the latter case the difference of potential at the terminals of the condenser may become so great as to rupture the dielectric, notwithstanding the fact that the terminals are joined by a conductor

FIG. 22.—Type of Bulb without Leading-in Wire.

of low resistance. It is, of course, not necessary, when it is desired to produce the incandescence of a body enclosed in a bulb by means of these currents, that the body should be a conductor, for even a perfect non-conductor may be quite as readily heated. For this purpose it is sufficient to surround a conducting electrode with the non-conducting material, as, for instance, in the bulb described before in Fig. 21, in which a thin incandescent lamp filament is coated with a non-conductor, and supports a button of the same material on the top. At the start the bombardment goes on by inductive action through the non-conductor until the same is sufficiently heated to become conducting, when the bombardment continues in the ordinary way.

(To be continued.)

ON THE CAUSE OF THE CHANGES OF ELECTROMOTIVE FORCE IN SECONDARY BATTERIES.*

BY J. H. GLADSTONE, PH.D., F.R.S., MEMBER, AND WALTER HIBBERT, F.I.C., ASSOCIATE.

In 1882, Dr. Gladstone and the late Mr. Tribe sent to *Nature* four letters on the "Chemistry of Secondary Batteries." The main point established in those papers was the all-important functions of sulphate of lead. They showed, in fact, that when a lead lead peroxide cell is discharged, "sulphate of lead is the ultimate product on both plates," and when it is charged again, "this lead sulphate is oxidated on the one plate, and reduced on the other." In 1883, another letter appeared, in which, among other things, the effect of different strengths of acid when the cell is being charged was investigated, and the existence of occluded hydrogen, ozone, and hydrogen dioxide was considered. These letters were subsequently published in book form.† In a paper of the same authors in the *Journal* of the Chemical Society for 1883, p. 345, reference was made to the production of persulphuric acid in the electrolysis of oil of vitriol.

In 1883, Prof Frankland‡ obtained substantially the same results, and proposed to ascertain the state of a cell during charge or discharge by observing the density of the acid. In 1889, Messrs. Duncan and Wiegand§ investigated the rate of diffusion of the acid out of the pores of the spongy masses in the plates of a secondary battery. In 1889, Heim¶ investigated the change in capacity of secondary batteries when used with different strengths of acid and gave the E.M.F.'s observed when the strength varied from 10 to 35 per cent. H_2SO_4. In 1890 we published experiments which led us to regard the "abnormal initial E.M.F. of a secondary battery as due to inequality of acid strength, and its gradual disappearance as due to equalisation of strength produced by diffusion." Shortly after this an elaborate and valuable series of observations on accumulators was published by Messrs. Ayrton, Lamb, Smith, and Woods,** who have given curves showing the changes in potential difference under many conditions of working. They allude to our suggestion, and conclude on various grounds that it is insufficient to explain some of the phenomena. In the discussion which followed this paper Mr. Hibbert urged that curves given by the authors afforded confirmation of our hypothesis. Subsequently, two papers were sent to the Royal Society by Mr G. H. Robertson and Prof. Armstrong,†† of which only the abstracts have been printed. From these, as well as from a lecture by Mr. Robertson at the Society of Arts,‡‡ we gather that they attribute much to the formation of persulphuric acid and hydrogen dioxide.

We have lately been making additional experiments on the matter, which have led us to the conclusion that variations in the strength of the sulphuric acid are the main cause of the variations in E.M.F. We proposed to consider: First, what variations of strength of acid actually occur during charge, repose, and discharge; second, experimental determination of the change of E.M.F. produced by changing the strength of acid; third, how far this is capable of explaining all that is known about the changes of E.M.F.; fourth, confirmations, experimental and theoretical; fifth, other suggested causes.

PART I.—WHAT VARIATIONS OF STRENGTH OF ACID ACTUALLY OCCUR DURING CHARGE, REPOSE, AND DISCHARGE.

(*a*) *Changes During Charge.* If we start with a properly formed cell which has been discharged, we have to deal with two leaden supports, on one of which there is a mixture of lead sulphate ($PbSO_4$), with more or less lead peroxide (PbO_2), and on the other a mixture of lead sulphate ($PbSO_4$), with more or less spongy metallic lead. Each of these mixtures is a porous layer the interstices of which may penetrate to the leaden support. To avoid confusion, we propose describing the one as the PbO plate, and the other as the Pb plate. If these be charged, the chemical action consists of the conversion of the lead sulphate on the one plate into PbO_2, and on the other into spongy lead, and the electrolytic change may be expressed thus:

$$PbSO_4 + H_2O \;.\; H_2O + PbSO_4 = PbO_2 + H_2SO_4 \;.\; H_2SO_4 + Pb.$$

It is evident that during this process sulphuric acid is formed in the pores of both plates, whilst at the same time an equivalent amount of water disappears. Apart from this electro-chemical result, which is equal on both sides, it is well known that during an electrolytic decomposition there is a gradual heaping up of the acid at what is now called the positive electrode, and a drawing of it away from the other. This increase of strength of acid at the peroxide plate may be seen by the descent of a denser layer of acid through the clear space under the plate. Indeed, it is well known that there is a circulation in the cell, the acid becoming stronger at the bottom and weaker at the top. But to remove any doubt as to the strength of acid in the pores of the peroxide being greater than in those of the other plate, we made a direct experiment. A cell was made of two small fully-formed plates, each in a porous pot containing about 30 cubic centimetres of acid. These porous pots were placed in a large dish of the same acid and a current of 0·2 ampere sent through for two hours. After that time, the acid in the pot containing the PbO_2 plate had increased 3 per cent., whilst that round the Pb plate had diminished 1 per cent. Of course, during the whole process of charging, diffusion is tending to equalise the strength of the acid, but it is much impeded by the capillary nature of the passages through which it must take place. It is quite conceivable that towards the end of charging, a film of the strongest acid—that is, H_2SO_4 itself—covers the working surface of the PbO_2 plate. All these actions account for the well-known fact that during the charge the whole body of the liquid in a working cell rises in density by somewhere about 0·04.

(*b*) *Changes on Repose.*—At the end of charging, the PbO_2 plate consists of porous peroxide attached to the lead support, surrounded by strong sulphuric acid. This sulphuric acid will diffuse out into the intermediate liquid at a rate which Messrs. Duncan and Wiegand's results show to be rapid at first. Complete equalisation is, however, a very slow process, to be reckoned by hours rather than by minutes. But there are other actions reducing the sulphuric acid in the pores at the same time. The PbO_2 and its supporting lead are in a condition to set up energetic local action with the formation of sulphate of lead, and consequent absorption of sulphuric acid from the liquid. The chemical change is as follows:

$$PbO_2 + H_2SO_4 \ldots\ldots H_2SO_4 + Pb = PbSO_4 + H_2O \ldots\ldots H_2O + PbSO_4.$$

(It must be remembered that the Pb in this equation is the lead support for the peroxide. Common experience shows that it is corroded during use.) This action clearly will absorb sulphuric acid from the liquid in the pores and replace it by water. In a well-charged plate, there is always at first an evolution of a little oxygen gas, which has been attributed* to the reaction of hydrogen dioxide on peroxide of lead.

$$PbO_2 + H_2O_2 = PbO + H_2O + O_2.$$

If this be the case, the oxide of lead (PbO) formed must also abstract its equivalent of sulphuric acid from the liquid.

Of the three causes of weakening—diffusion, local action, and reduction by H_2O_2—the first goes on till the acid in the pores is brought down to the same strength as that in the intermediate liquid. But the local action may still continue for many days, and will tend to keep the acid in the pores a little weaker than that in the external liquid, notwithstanding the return diffusion of acid towards the plate. Turning now to the Pb plate in repose, we find none of the above actions taking place, except the slow equalisation of strength produced by diffusion. But there is an action peculiar to this plate that is, a direct, slow chemical action of the sulphuric acid on the lead, producing lead sulphate and hydrogen gas.† The equation is—

$$Pb + H_2SO_4 = PbSO_4 + H_2.$$

This must gradually produce a weakening of the acid in the pores, and it is important to notice that diffusion, which is always slow, will be almost entirely prevented by the choking up of the capillary passages by the gas evolved. We have indicated the probability that towards the end of a charge there is a film of the strongest acid against the working surface of the PbO_2 plate. If this be true, it is evident that as soon as repose begins such a film will almost immediately disappear, owing to diffusion into adjacent liquid, whether in the pores or out of them.

(*c*) *Changes During Discharge.*—As soon as the discharge begins, a still more rapid reduction of the strength of acid may be expected. Diffusion, local action, and reduction by H_2O_2 will still take place on the PbO_2 plate, and the direct chemical action on the Pb plate, but on each plate there is superadded the ordinary discharge reaction of the cell. The form of the equation for discharge is the same as that already given for local action—namely:

$$PbO_2 + H_2SO_4 \ldots\ldots H_2SO_4 + Pb = PbSO_4 + H_2O \ldots\ldots H_2O + PbSO_4.$$

(In this case the Pb represents spongy lead on the Pb plate.)

But while the absorption of sulphuric acid and production of water thus goes on in both plates, electrical transference of the H_2SO_4 now takes place from the PbO_2 to the Pb plate, causing an additional weakening of the acid in the pores of the first. If discharge has commenced immediately upon the cessation of charging, these different causes will combine to produce a very rapid decrease in the strength of the acid at the PbO_2 plate. In any case, a period must soon arise in which the great excess of sulphuric acid originally about the PbO_2 plate has disappeared through these various agencies, and the acid on both plates will be reduced to pretty nearly the same strength as that of the intermediate liquid. After this, there will be a gradual withdrawal of acid from the liquid in the pores, more or less compensated by diffusion inwards from the intermediate liquid. This, of course, brings about the reduction in the strength of the whole acid, which is well known to take place during discharge.

The strength of the acid in the pores will be determined by the relative values of the rate of withdrawal and the rate of diffusion. But while the rate of withdrawal continues constant for a given discharge current, the rate of diffusion rapidly diminishes.‡ The rate of weakening of the acid is therefore a constantly increasing one, and may finally become so rapid that the acid strength of the

* Paper read before the Institution of Electrical Engineers.

† "The Chemistry of Secondary Batteries." Macmillan, 1883.

‡ *Proc.* Roy. Soc., vol. xxxv., p. 67.

§ *Electrical World*, June 15, 1889. ¶ *El. Zeit.*, 1889, p. 88.

‖ "Notes on Secondary Batteries," *Phil. Mag.*, 1890, p. 163.

** *Jour.* Inst. Elec. Engineers, 1890, pp. 539 and 660.

†† *Proc.* Roy. Soc., 1891, pp. 105 and 108. ‡‡ Soc. Arts *Journal*, December 4, 1891.

* "Chemistry of Secondary Batteries," p. 51.

† Gladstone and Hibbert, *Phil. Mag.*, 1890, p. 164; Ayrton and others, *Journal* Inst. Elec. Engineers, 1890, p. 680.

‡ This might be expected from the partial clogging of the pores by the $PbSO_4$ formed on both plates, and it has been experimentally shown to be the case by Messrs. Duncan and Wiegand.

liquid against the working surfaces of the plates is very low or almost *nil*. In such a case we may expect the formation of the white compound described by Gladstone and Tribe,* which when analysed seemed to be a basic compound of the composition $2PbSO_4.PbO$.

(*d*) *Changes on Repose after Prolonged Discharge.*—If through prolonged discharge the acid against the working surfaces has become very weak, and the discharge is then stopped, it is evident that the acid in the pores will quickly increase in density, and uniformity of strength in and outside the pores will be restored after a while; but the general strength will always be lower than the original value. A renewal of the discharge will, however, soon lead to exhaustion of the acid against the working surfaces.

Part II.—Experimental Determination of the Change of E.M.F. Produced by Changing the Strength of Acid.

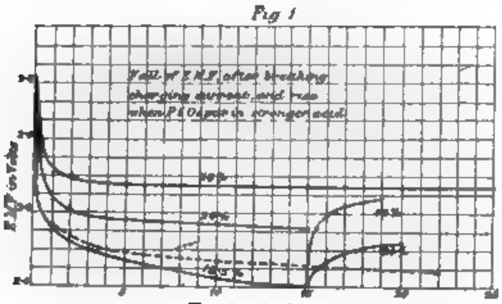
It is a matter of general knowledge that the E.M.F. of an accumulator rises slightly when the strength of the acid is increased. Incidental determinations of the rise occur in several papers, of which we may mention one by Preece† and another by Heim.‡

In 1890, thinking it probable that the chief cause of the high E.M.F. was "the great inequality in strength of acid produced by the charging current," we made some experiments which were described, with tabulated results, before the Physical Society.§ Instead of repeating these we now throw the results into a diagram of curves, Fig. 1.

For each case the ordinates represent E.M.F. of the cell in volts, the abscissæ represent time in minutes. The figures attached to the curves show the percentage strength of the acid round the PbO_2 plate. The Pb plate was always in 18·5 per cent. acid.

The curves show—First. That in each experiment the E.M.F. at the commencement of discharge is about the same value, 2·58 or 2·6. Secondly. That the fall after stopping the charging

Fig 1



Time in minutes

current was initially more rapid in the case of the weaker acid. The subsequent and more permanent E.M.F. also depends on the strength of the acid, the value for 58 per cent. acid being 2·27 volts; for 34 per cent. acid, about 2·15 volts; for 18·5 per cent. acid, about 2·01 volts. When the cell has been in repose 15 minutes, the weakest acid gave 0·26 volt less than the strongest, and 0·14 volt less than the 34 per cent. acid. Thirdly. That if, when the E.M F. has fallen, the strength of the acid be increased, the E.M.F. quickly rises, and as the acid soaks into the pores, eventually attains about the same value as if that particular strength of acid had been maintained throughout.

This seemed to justify our conclusion, but we were desirous of obtaining more direct evidence of the effect of varying strength of acid. In our old experiments we measured E.M.F. by the condenser method, and have again found it useful in many experiments. But we now have made more accurate determinations by the potentiometer, and in one series of experiments by observing the current obtained through a high resistance.

Throughout the new experiments we have employed the same two plates. The supports consisted of thick lead wire doubled on itself. These were pasted with red lead and then "formed" in the usual way, until the paste on one was pure lead, and on the other pure peroxide of lead. The active part of each was about 3in. long and ½in. diameter. The containing vessel and acid varied according to requirement, as described below for the particular experiments. We found that on transferring the plates from a weaker to a stronger acid the E.M.F. begins to go up, at first rapidly, afterwards more and more slowly. But the final value is not reached for some hours. It was impossible to allow so much time for each observation, and in our earlier experiments we made our determination of E.M.F. at the end of 20 minutes or so. Consequently in these our figures do not represent the ultimate value of the E.M.F. for that strength of acid, but they do not fall much short of it. In all experiments the plates were fully charged, and before being used was washed free from the liquid products of electrolysis.

First Series.—In the first series both plates were immersed in acids of the same strength. When one observation had been made, the plates were quickly transferred to another cell containing stronger acid, and the E.M.F. occasionally tested for 15 minutes, when it was finally observed, and the plates again removed into a cell containing still stronger acid, and so on. The following table gives the results:

Table I.

Acid in cell round both plates. Density.	Percentage strength.	E.M.F. of cell in volts.
1·045	6·5	1·887
1·065	9·5	1·898
1·080	11·5	1·915
1·115	16·2	1·943
1·157	21·7	1·978
1·217	29·2	2·048
1·254	33·7	2·068
1·335	43·0	2·170

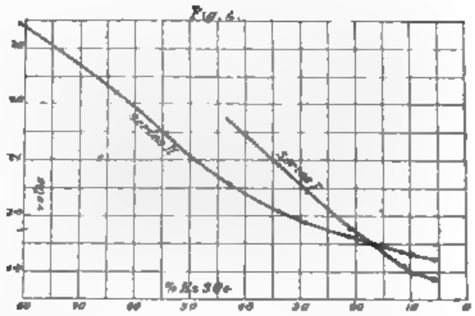
The last acid was found to act vigorously on the spongy lead, so that this series was discontinued.

Second Series.—The same procedure was followed, with the exception that the Pb plate was kept throughout in acid of density 1·098 = 14 per cent. The peroxide was transferred from one to another of a series of porous pots filled with acids of the strength given below:

Table II.

Acid round PbO_2 plate. Density.	Percentage strength.	E.M.F. in volts.
1·045	6·5	1·926
1·065	9·5	1·932
1·080	11·5	1·939
1·115	16·2	1·949
1·157	21·7	1·963
1·217	29·2	1·986
1·254	33·7	2·013
1·335	43·0	2·061
1·53*	63·0	2·22
1·75*	81·0	2·33

* The two last observations really belong to another set of experiments, where the acid round the lead = 23 per cent.



The results of the two series are plotted in the diagram Fig. 2. It will be seen—first, that in both cases the E.M.F. increases with the strength of the acid, although in Curve II. there is no change in the acid at the Pb plate; secondly, there is no coincidence of the curves except where the conditions of the experiments are practically identical; thirdly, that for any given abscissa the E.M.F. in Curve I. is smaller than that in Curve II. when the acid about the Pb plate is less than 14 per cent., and greater when it is more. Hence it follows that the E.M.F. depends on the strength of the acid at both electrodes.

Table III.

Time of soaking.	Density of acid.	% H_2SO_4.	E.M.F. in volts. Ascending.	Descending.	Mean.
1 hour ...	—	Trace	—	1·507	1·507
"	1·008	1·2	1·747	1·777	1·762
"	1·013	2·0	1·792	1·825	1·808
"	1·020	3·1	1·835	1·867	1·851
"	1·037	5·6	1·875	1·906	1·891
30 minutes	1·071	10·4	1·922	[illegible]	1·937
"	1·154	21·3	1·993	2·016	2·004
"	1·233	31·2	2·055	2·066	2·060
15 minutes	1·388	49·0	2·149	—	2·149

Third Series.—Not being satisfied with the range or the accuracy of the preceding series, we endeavoured to obtain a curve representing the relation between E.M.F. and strength of acid within the widest limits. After preliminary trials and considerations, we adopted the following plan. The experiments were divided into two parts, in consequence of the action of strong acid on spongy lead. In the first part we commenced with an acid of 5·6 per cent., and worked upwards to 49 per cent., allowing the plates to stand half an hour in each acid before final observation of E.M.F. The process was then reversed, working downwards through the same acids to 5·6 per cent. again, and then continued through weaker acids to a mere trace—less than 0·05 per cent.—and the cycle finished by returning once more to 5·6 per cent. As even half-an-hour or an hour is scarcely sufficient for equalisation of the strength of the acid within and without the pores of the plates, it may be expected that the ascending series would scarcely represent the full effect of the rise, whilst the descending series

* "Chem. of Sec. Batts.," p. 46.

† *Proc.* Roy. Soc., 1883, p. 460. ‡ *El. Zeit.*, 1889, p. 88. § *Phil. Mag.*, 1890, p. 168.

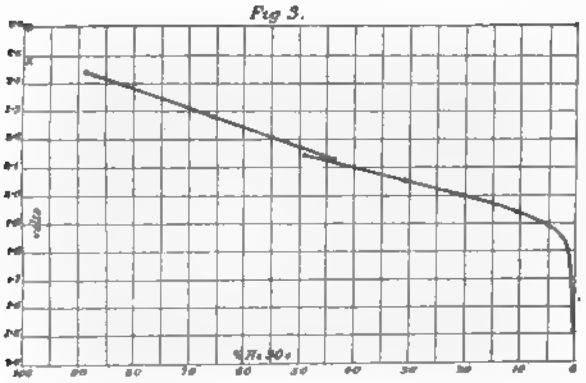
would scarcely represent the full effect of the fall. We therefore give in Table III., not only the numbers actually obtained, but also the means of the ascending and descending series, which cannot be far from the true values. We have proof of this in the case of the 5·6 per cent. acid, where the mean is 1·89 volts, while the true E.M.F., as very carefully determined previously for the same strength, was 1·88 volts. This agreement also proves that no appreciable change had come over the plates during the operations.

In the second part of the experiments of this series, the Pb plate stood throughout in 27 per cent. acid. We commenced with the PbO_2 plate in 43·5 per cent. acid, ascended to 88·5 per cent., and then returned to 43·5 again. A longer time was here allowed for diffusion, as the strong acid is very viscid. Notwithstanding this longer soaking, the differences between the ascending and descending series are greater than before. The results are given in the following table:

TABLE IV.

Time of soaking peroxide plate.	Acid round peroxide.		E.M.F.		
	Density.	% H_2SO_4.	Ascending.	Descending.	Mean.
50 minutes	1·338	43·5	2·106	2·163	2·135
50 ,,	1·446	54·8	2·179	2·233	2·206
50 ,,	1·569	66·0	2·259	2·298	2·277
60 ,,	1·605	69·0	2·279	2·342	2·310
60 ,,	1·723	79·0	2·354	2·398	2·376
60 ,,	1·814	88·5	2·442	—	2·442

The mean results of Tables III. and IV. are given in the diagram Fig. 3. The two curves very nearly join, and when it is considered that the highest E.M.F. of the lower curve is almost certainly too low, and the lowest E.M.F. of the upper curve too high, the coincidence is striking.



An attempt was made to get an observation in a very strong acid. The fully-charged PbO_2 plate was washed in water, and dried at 100deg. C. It was then soaked in 95 per cent. acid. After 34 minutes' soaking, the E.M.F. was observed, and the plate then placed in weaker acid. In consequence of absorption of water from the adjacent liquid of the cell, as well as from the atmosphere, the acid round the PbO_2 plate fell to 91·5 per cent., the Pb plate standing all through in 27·5 per cent. acid. Results are given below, and are fairly confirmatory of the previous figures:

TABLE V.

Time of soaking.	Acid round PbO_2 plate.	E.M.F.
34 minutes	91·5 per cent.	2·44
63 ,,	77·5 ,,	2·37
67 ,,	65·5 ,,	2·28
97 ,,	53·0 ,,	2·16

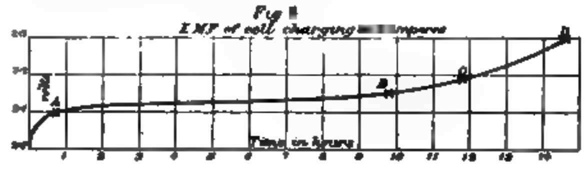
The highest E.M.F. here obtained (2·44) is very nearly the same as that given in Table IV. for 88 per cent. acid.

A still further effort was made to get an observation in the strongest acid. A PbO_2 plate was soaked all night in 80 per cent. acid, and in the morning transferred to a jar containing 99 per cent. H_2SO_4. This was kept under a closed bell jar for four hours, after which the E.M.F. between the PbO_2 in this strong acid and a Pb plate in 25 per cent. acid was measured by potentiometer. The value was 2·47 volts, which, after 30 minutes further standing, rose to 2·48 volts nearly. This is represented in Fig. 3 by the small cross ×. It was expected that a still higher voltage could be obtained if both plates were immersed in the strongest acid, undiluted H_2SO_4. The difficulty was that this acid acts pretty readily on the spongy coating of the ordinary Pb plate, so we made an experiment with a strip of ordinary clean sheet lead. Placing this in the same H_2SO_4 in which the PbO_2 plate had been standing for some hours, the E.M.F. was found to be as high as 2,607* volts. This is indicated in Fig. 3 by *.

* The same E.M.F. was obtained whether the lead was cleaned by scraping with a knife or by washing with acetic acid.

PART III.—HOW FAR ARE THESE RESULTS CAPABLE OF EXPLAINING ALL THAT IS KNOWN ABOUT CHANGES OF E.M.F.

At the very beginning, it is evident that the experiments described in Part II. more than cover the range of variation in E.M.F. during ordinary work. For these limits are: a maximum P.D. of 2·5 volts at the end of a charge, and 1·8 volts at the end of a discharge—figures which come within the variations produced by strong and weak acid. But our results go much farther than this, and for the purpose of detailed consideration we shall compare them (as shown in Parts I. and II.) with the valuable observations of Prof. Ayrton and his collaborateurs. Their papers in the *Journal* of the Institute* contain the most elaborate and trustworthy account of working variations of P.D. which has yet been published. In order to make the comparison more evident to the reader, we give the two following time curves of E.M.F. in charge and discharge. They are deduced from the curves of P.D. values given by Prof. Ayrton and others in the figures opposite p. 661, by making allowance for the resistance as exhibited on pp. 590 and 592. We indicate for certain marked points in the curves the percentage strength of the acid in the general body of the cell as deduced from the specific gravities given on pp. 672 and 673.



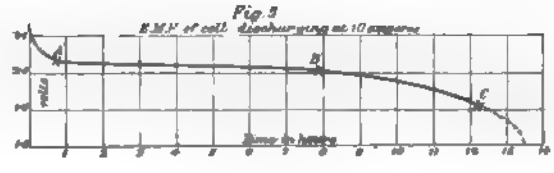
Acid in general body of cell during charge.

At point.	Density given.	% H_2SO_4.
A	1·178	24·5
B	1·198	27·0
C	1·201	27·4
D	1·206	28·0

Acid in general body of cell during discharge.

At point.	Density given.	% H_2SO_4.
A'	1·205	27·8
B'	1·189	25·9
C'	1·180	24·8

As far as charging is concerned, we have already shown that sulphuric acid must be continuously formed by the decomposition of the sulphate on each plate, and that the acid must become more and more concentrated, especially against the PbO_2 plate. If our views be correct, this must give rise to an immediate rapid increase of E.M.F.; but as the action proceeds the tendency of the heavy acid to sink towards the bottom of the vessel or to diffuse into the weaker intermediate acid, will become greater, and a point will be reached when the production of sulphuric acid against the plate will be nearly counterbalanced by its dispersal. The E.M.F. will still rise slowly, because the intermediate acid is gradually increasing in strength. This evidently is the tale that is told by Fig. 4. Beginning with an external acid of 24·6 per cent., and a corresponding E.M.F. of about 2·03 volts, there is a rapid rise—so rapid, indeed, that by the end of half-an-hour the E.M.F. has become 2·1 (which is about equal to what would be given by a 40 per cent. acid at each plate—see Fig. 3), whilst the intermediate acid has not risen, but is only 24·5 per cent. The increase of E.M.F. due to increase of strength of acid against the plates then becomes very slow; but after about nine hours it is found to have risen to what we may look upon as 45 per cent. or



more against the PbO_2 plate, while the intermediate acid in the cell has risen to 27 per cent. It subsequently rises against the working surfaces of the plates to 55, and eventually to at least 66 per cent., or probably much more, though the strength is little increased in the body of the cell.

When discharge commences, we have shown that there must be a very rapid weakening of the acid from diffusion and formation of lead sulphate, till the losses are fully counterbalanced from the intermediate acid. There will then be no material reduction till the intermediate acid is considerably reduced or prevented diffusing freely into the pores of the plates. This is the explanation of Fig. 5. We see the rapid fall of E.M.F., the bulk of which takes place in the first few minutes (see Ayrton and others, pp. 545 and 546, and our experiments, Fig. 1). After about half an hour the E.M.F. is reduced to about 2·03 volts, indicating about 25 per cent. H_2SO_4 against the plates, while the intermediate acid is 27·8 per cent. This state of things lasts for some hours, but the absorption of the free acid that is in the pores of the plates gradually reduces the strength there

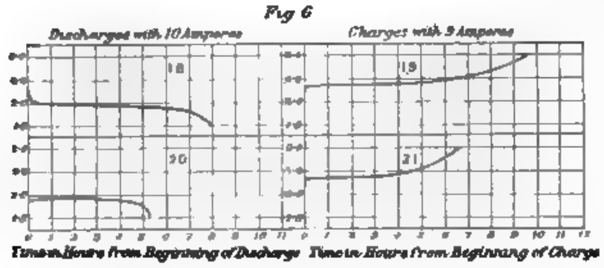
* *Loc. cit.*, pp. 661, 545.

below that of the intermediate liquid, so that after eight hours the internal acid is about 22 per cent., while the external strength has sunk only to about 26 per cent. The acid against the plates then declines more rapidly, so that in four hours more the E.M.F. is equal to that which would be given by 7 per cent. at each plate, while the intermediate acid has scarcely sunk below 25 per cent.

We have already mentioned in Section I. that when the acid is very weak the compound $2PbSO_4 PbO$ may begin to form. Should this be the case, the acid absorbed per ampere-hour would be less than before by about one-third. This is about what was found by Dr. Frankland, and described by him in the discussion on the paper by Prof. Ayrton and his colleagues (*Journal* Institute, xix., 698). Dr. Frankland shows that in some prolonged discharges there was some such reduction of the absorbed acid, and that the diminished rate of absorption began when the voltage fell below 1·8—a figure indicative, on our hypothesis, of a weak acid in the pores of the plates. We have also shown that if through prolonged discharge the acid in the pores has become very weak, a stoppage of the discharge ought soon to bring up the acid towards what it is outside. The E.M.F. ought therefore quickly to increase to the normal, or nearly so. This rise after rest was observed in very early days, and has been frequently discussed, as, for example, by Messrs. Gladstone and Tribe ("Chem. Secondary Batts.," p. 28), and by Prof. Ayrton and others.

We have already seen that if a charged cell be allowed to rest without discharge, the acid in the interstices of the Pb plate is slowly weakened by its action on the lead with the evolution of hydrogen gas. The gas will tend to clog the interstices and impede the stronger acid outside from diffusing inwards.* The

Fig 6



lower strength of internal acid will produce a lower E.M.F. than would be obtained if the internal acid were of the same strength as the external. In other words, a discharge after long repose ought to commence with a somewhat low E.M.F. But one effect of discharging will be to remove the impediment to free diffusion produced by the enclosed gas, and thus tend to increase the strength of the internal acid, with a consequent small rise in E.M.F. as the discharge goes on. Now Prof. Ayrton and his colleagues obtained these very results in two instances. The curves representing one of these we have reproduced, Fig. 6, from their paper, with two previous normal curves, *a* and *b*, for comparison. In both the instances not only had the P.D. sunk below the normal during repose, but it never quite recovered its normal value, while the fall towards the end of the action took place in about two-thirds of the normal time. On subsequent charging the process of decomposing the $PbSO_4$ lasted for only two-thirds of the usual time. All this points to an early clogging of the pores, and a consequent diminution of the total chemical action. In this way we explain what the discoverers of the effect regard as a difficulty. The real problem that had to be solved was not why did the P.D. go up during discharge, but why had it gone down during the many days' repose?

(*To be continued.*)

DUNDEE ELECTRIC LIGHTING.

It will be seen from our advertisement columns that the work at Dundee will soon commence. The following is the report of Prof. A. W. B. Kennedy upon the scheme of Messrs. Urquhart and Small, who are the engineers to the Corporation:

Having now received from Messrs. Urquhart and Small their specifications for this work in their final form, I have pleasure in forwarding to you my report on the matter.

I had submitted to me, in the first place, a copy of your provisional order and other documents, a map of the permissory and scheduled districts, Messrs. Urquhart and Small's six specifications, (those, namely, for boilers, pipes, etc., engines, dynamos, batteries and mains), and their drawings of the station arrangement. I visited Dundee on the 19th April (after having examined these papers), and there had the advantage of meeting several members of your body, with whom I discussed the whole question informally. I also examined the proposed site for the station, and walked over the whole of the lines along which it is proposed to lay mains, in the company of Mr. Urquhart.

As to the general question of the best system to be used, Messrs. Urquhart and Small recommend a low-tension continuous-current system arranged with three-wire mains, and having storage batteries in the circuit for light loads, etc. This is the system which I have myself used for some years in London very successfully, and on which I am now carrying out the lighting of Glasgow. I was disposed to think that the work at Dundee might have been carried out on the simpler two-wire plan, which I am arranging in Oldham for a station very similar in output to that at Dundee, but on examining the site of your station in reference to the districts which are to be lighted, I think it will be more economical for you to adopt the three-wire system as proposed.

The whole of the business parts of Dundee, as well as the important residential district to the north-east of the station, can be very easily supplied from it direct on this system. Should it be required, later on, to supply the Perth-road district, this can readily be done from the station by the use of a motor-transformer, with or without a battery of accumulators, in a small local substation fed by mains from the central station.

As to the specifications themselves, I have to say that I have examined these most minutely, and have advised a number of changes in their details, which have all been carried out and embodied in the final copies sent to me by Messrs. Urquhart and Small on the 7th instant. I have pleasure in saying that in their present form I approve them, and think them thoroughly satisfactory.

The changes I have referred to were for the most part in details of the work, and were purely technical, so that I need not trouble you with any particulars about them. I will only mention, as points of greater importance, the substitution of single dynamos running at 230 volts pressure for pairs of dynamos in series at half that pressure; a reduction in the size of the two smallest dynamos and engines, to adapt them better for economical working at the lowest loads; some considerable modifications in the specification for batteries (mainly in the direction of demanding increased efficiency); and some increase of the amount of copper in the smaller mains.

I notice that Lancashire boilers are specified, and that the specification for the boilers has been prepared by Mr. Michael Longridge, who is of course an excellent authority on these matters. No boilers are more satisfactory or more economical than these, when they are not too hard worked, and where there is plenty of room for them, and I understand that in Dundee you are not troubled with the extremely sudden fogs to which we are subject in London, and which render necessary the use of a boiler which allows of a somewhat more rapid raising of steam. On the face of the drawings it appeared to me that the long boilers somewhat unduly restricted the space available for unloading and turning the coal carts, but I understand that you have made actual experiments as to the space required by such carts as are commonly in use in Dundee, and have satisfied yourselves that the space allowed is ample. Under these circumstances, I have nothing further to say on this head. In my own practice, where economy of space has been an important matter, I have used multitubular boilers (about 8ft. diameter and 14ft. long) of the dry back marine type, set in brickwork, and found them to work in every way admirably, and to be most economical in their results.

The Perret grate, which you propose to employ, I have frequently seen at work, and believe that it has been found very successful.

I may point out to you that economy in working an electric lighting station depends very largely indeed on the number of hours during which the load can be kept fairly heavy, a period which is, unfortunately, very short in any case. It is therefore of great importance to you that your customers should be as varied as possible, so that when one section has done with the light another may be taking it up. In your scheduled area there appear to be very few private houses; the consumption must take place altogether in shops and offices. The latter close very early indeed, and the shops not late. If, therefore, you were encouraged by, or could encourage, any demand for light in the residential district above the station, it would be very advisable for you to extend your mains there, so that you might get the benefit of the house lighting after the shops, and still more after the offices were closed.

I have not yet seen Messrs. Urquhart's and Small's switchboard specification, although I have discussed this matter also in general terms with Mr. Urquhart. I shall be very happy to examine it if it is sent to me, but there can be nothing in it which will affect what I have said in this report, which, therefore, I do not delay.

In conclusion, I need only express the opinion which I have already expressed in a letter to Mr. Thornton, that Messrs. Urquhart and Small have proposed to you a well thought out scheme, and one of a type which has been thoroughly tested and found to be efficient and economical in practical work, and that, as far as I am able to judge, the system proposed is that best adapted for the particular conditions of your city.

Ruabon.—Messrs. Hughes and Lancaster, engineers, Chester, are removing their works to larger and new premises at Acrefair, near Ruabon. These works will be electrically lighted by a Crompton arc-lighting dynamo, and the Brockie-Pell arc lamps, 16-hour type, for the interior of works and foundry. The work has been carried out by Mr. W. Sillery, of Wrexham, to the specification of the consulting engineers, Messrs. Hughes and Hill, 5, Parsonage, Manchester.

* There may also be a slow formation of lead sulphate on either plate, due to the local action described further on.

COMPANIES' MEETINGS.

CHELSEA ELECTRICITY SUPPLY COMPANY, LIMITED.

On Thursday last week the ordinary general meeting of the shareholders of this Company took place at the offices, Draycott-place, under the presidency of Mr. J. Irving Courtenay.

The **Secretary** (Mr. S. J. Cluer) having read the notice convening the meeting,

The **Chairman** said: Gentlemen, the accounts before you represent the result of the second complete year of work; and you will, I think, agree with me that, considering the numerous obstacles a pioneer company is bound to encounter, the result is encouraging. No one who realises the difficulties of working up a business of this nature will be surprised at our not being able to pay a dividend as yet in addition to the debenture interest, but we are now in a fair way of earning some return on the ordinary share capital. The gross revenue is 67½ per cent. more than that for the preceding year, but the gross profits are more than three times as large as those of 1890. These profits have been mainly used for the payment of the debenture interest and the extinction of the suspense account. Although the improvement is great, we are convinced that a still greater improvement can be made. Much has already been done of which the benefit is scarcely felt in these accounts, as the alterations put in hand early in the year were not completed until December. The result of this was that during the greater part of last year the work was only carried on under the old disadvantageous conditions, but the difficulty of supply was also enhanced by the alterations going on at the same time. Notwithstanding these adverse circumstances, the improvement in the last three months of the year, as pointed out in the Directors' report (*vide* pp. 478-9 of our last issue) has been most marked, the current having been produced for the last quarter of 1891 at 33 per cent. less than the average of the previous nine months. I am, however, happy to say that our resident engineer, Mr. Talbot, has successfully overcome all the difficulties of the situation, and has maintained an efficient supply. I may mention that on December 31 last the expenditure for each lamp installed was only £2. 14s. 6d., and it is now less. During the last two years we have obtained an increase of about 20,000 lamps, the total number now standing at over 30,000. The lamp density in the area supplied by the Company is extremely good. At the end of 1891 there were 4,583 lamps installed for every mile of street in which the mains are laid, or 2·6 lamps per yard. The proportion of houses lighted in the streets in which mains are laid is one-quarter to one-third of the total number of houses. The plant is all in good working order, and the cost of maintenance has been moderate. The maintenance of generating plant is 3 per cent.; of buildings, just over ½ per cent.; of mains, $\frac{1}{10}$ per cent.; and of meters, 2½ per cent. on the capital expenditure. The maintenance of accumulators and accessories amounts to about 2½ per cent. of the capital expenditure on them; but I may remind you of what I have stated on a previous occasion, that the maintenance of accumulators includes the complete renewal of the plates, which are practically the only parts that wear out. The capacity of the present plant in ordinary weather is over 40,000 lamps, but as, in this part of London particularly, we have to take into account prolonged foggy weather, we have to allow a large margin, which reduces the safe capacity to, say, 33,200 lamps. By an expenditure, however, of about £1,600 this capacity could be increased to 36,200 lamps, and, by laying out a further sum of about £1,000, to 38,350 lamps. The introduction into our system of the continuous-current transformer, which was initially arranged as part of the system by Mr. Frank King, and which was viewed by some authorities as somewhat in the nature of an experiment, has proved a permanent success. Apparatus of this class had not previously been used for the purposes of general electricity supply; and it is gratifying to note after two and a-half years' experience that they work most steadily and efficiently, and at a very low figure for maintenance. These are now made by the Electric Construction Corporation at Wolverhampton. We have not carried out the extension of our mains as contemplated when I last addressed you, and consequently our income has not been as large as was then estimated. I will now endeavour to give you an estimate of the revenue for this year. Taking only the additions to the lights which we now have in view within our present area, and calculating on the basis of the results of 1891, the gross revenue from current alone should amount to over £13,000, as against £9,681 for 1891, an increase of 34 per cent., without entering upon fresh territory. A profit of 2½d. per unit on this output would realise a sum sufficient to pay debenture interest on—say, £35,000—and a 4 per cent. dividend on the share capital. There is, however, yet room for a substantial increase in the number of lamps where the mains are laid. As I have before mentioned, nearly all new houses in this district are wired for the electric light. This bears upon a question which has been rather fully discussed—the reluctance to take the electric light among a number of people who do not care to incur the expense of having their houses wired, especially where the leases have only a short time to run. During the first quarter of the year we have obtained an increase of over 2,500 lamps. The revenue account for that quarter fully bears out the estimate I have just given you of the revenue for the current year. Our figures are based on a return per 8 c.p. lamp of 9s. per annum, an amount likely to be increased as more shops and trading premises come on the circuit. We are still giving our close attention to improvements in economy of working, and are continuously taking careful tests of results. The supply has already been acknowledged to be the best for the consumer, and it is second to none in steadiness and in quality; and we believe that a system of supply which is popular with the consumer must succeed in the end in giving satisfactory returns to the shareholders.

The report and accounts were adopted after a short discussion.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

Mr. W. S. Andrews, at the meeting of this Company, at Winchester House, last Thursday, moved the adoption of the report. There had, he said, been an increase in the traffic, but the money produced had been diminished to the extent of £16,472; but this was explained by the loss in exchange, the difference between the last and the preceding year being as between £731 and £19,133. But for the difference in exchange the money earned would have been much larger. The lesser dividend (4 per cent.) was entirely due to this circumstance. They had been threatened with competition, but up to now the French line did not appear to have done them much harm. They had duplicated their lines from end to end, with the result that they had the capacity of three cables, and they had now a line of 2,235 miles, which had been duplicated without any addition to the capital of the Company. On the whole, he felt that their financial position was not unsatisfactory. The public did not appear to be dissatisfied with the services rendered by the Company, and, notwithstanding opposition, he thought they would eventually find out that Codlin was their friend, not Short.

Mr. C. W. Earle seconded the motion, which was adopted, and Mr. Copping was subsequently elected a director.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.

On Tuesday the thirtieth ordinary general meeting of this Company was held at Winchester House.

Mr. C. W. Earle (the chairman) moved the adoption of the report. He did not think, he said, that any shareholder who was present at the last meeting would be surprised at the report now presented. They would see that the traffic receipts for the half-year had decreased by some £7,350 as compared with the corresponding half of the previous year, and this was due to the reduction of rates and the condition of the West India trade. It was also shown that there had been a heavy increase in the cost of repairs, amounting to over £15,000. Of this the sum of £2,119 had been taken from the reserve fund. This was necessary to pay for the laying of the new cable between Trinidad and Demerara, which completed the duplicating of their system. They had already reaped some benefit from this. With regard to the future, although they might reasonably look for an increase in business, owing to reduction of rates, he was sorry to say the number of words had decreased under the new tariff rather than the reverse, and when the condition of the West India Islands was taken into consideration, and it was borne in mind that only a few of the inhabitants—the principal merchants—made use of their cable, he did not see much chance of improvement. He was glad to say they had issued their £80,000 5 per cent. debentures partly for payment of £50,000 old debentures, and the balance in part payment of the St. Vincent, Barbadoes, and Trinidad-Demerara duplicate cables.

Sir James Anderson seconded the motion, which was carried.

NEW COMPANIES REGISTERED.

Abell's Electrical Engineering Company, Limited.—Registered by Barlow and James, 49, Lime-street, E.C., with a capital of £5,000 in £5 shares. Object: to acquire the undertaking of an electrical engineer, hitherto carried on by T. K. Abell and W. Hughes, at the steam factory, Raglan-street, St. Helens, Lancashire, and to carry on and extend the same in all its branches. Registered without articles of association.

London and Hampstead Battery Company, Limited.—Registered by H. P. Spottiswoode, 32, Craven-street, Strand, with a capital of £50,000 in £5 shares. Object: to acquire the undertaking of an electrical engineer and electrician, now carried on by A. W. Armstrong, at Finchley-road, Hampstead, N.W., with a view to the acquisition thereof; to accept a proposal made by the said A. W. Armstrong; and generally to carry on in Hampstead the business of an electric light and power company in all its branches. The first subscribers are:

	Shares
H. J. Peachey, 32, Craven-street, W.C.	1
W. E. Ruck, 31, Craven-street, W.C.	1
M. Hallett, 7, St. Martin's-place, W.C.	1
R. G. Fuller, 7, St. Martin's-place, W.C.	1
J. Hamilton, 157, West George-street, Glasgow	1
G. J. Rowley, 11, Candahar-road, Battersea	1
W. C. Hallett, 7, St. Martin's-place, W.C.	1

There shall not be less than three nor more than seven directors, the first being W. C. Hallett, R. J. S. Beeton, and A. W. Armstrong. Qualification, £500. Remuneration, £600, divisible as they themselves shall determine.

Mather and Platt, Limited.—Registered by Cooper, Dennison, and Co., 5, Shoe-lane, E.C., with a capital of £200,000 in £10

shares. Object: to acquire as a going concern the business of steel and iron founders, mechanical and electrical engineers, and millwrights now carried on by William Mather and John Platt at the Salford Iron Works, Salford, Lancashire, under the style of Mather and Platt, in accordance with an agreement expressed to be made between William Mather and John Platt of the one part and this Company of the other part, and generally to carry on the business of mechanical, electrical, and hydraulic engineers, steel, brass, and iron founders, millwrights, etc. The first subscribers are:

	Shares.
W. Mather, Salford Iron Works, Manchester	1
J. Platt, Salford Iron Works, Manchester	1
E. Hopkinson, Salford Iron Works, Manchester	1
C. Mather, Salford Iron Works, Manchester	1
T. Thorp, Salford Iron Works, Manchester	1
J. Milligan, Salford Iron Works, Manchester	1
A. W. Manson, Salford Iron Works, Manchester	1

William Mather, John Platt, E. Hopkinson, and T. Thorp are to be managing directors of the Company. Qualification: W. Mather and J. Platt, 1,000 shares; E. Hopkinson and T. Thorp, 250 shares. Remuneration, £4,000 per annum, divisible. Governing director, William Mather.

BUSINESS NOTES.

West India and Panama Telegraph Company.—The receipts for the two weeks ended May 15 show a decrease of £489 as compared with the corresponding period.

City and South London Railway.—The receipts for the week ending May 15 were £709, against £665 for the same period of last year, or an increase of £44. The total receipts to date from January 1, 1892, show an increase of £1,323, as compared with last year.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £2,635. The receipts of the West India and Panama Company for the half-month ended May 15 were £2,666, against £3,155.

PROVISIONAL PATENTS, 1892.

MAY 9.

8743. **Improvements in couplings for electric wires.** Alexander Shiels, 159, Coldharbour-lane, Camberwell, London.

8745. **Improvements in switches for electric light work.** Bernard Mervyn Drake and John Marshall Gorham, 66, Victoria-street, Westminster, London.

8768. **Improvements in and relating to mechanically-driven alternating dynamo-electric machines combined with an electric lamp.** William Phillips Thompson, 6, Lord-street, Liverpool. (Sante Hellebrandt, Austria.)

MAY 10.

8805. **Improvements in dynamo-electric machines and electric motors.** Herbert Napier Prentice, 47, Lincoln's-inn-fields, London.

8837. **An improved non-consumable electric light candle or a non-consumable candle for arc lamps.** Thomas Armstrong and Charles Hascall, 150, Battersea Park-road, London.

8838. **Improvements relating to the application of electricity to spring mechanism.** Adolph Edward Vidal, 20, Central-hill, Norwood, London.

8854. **Improvements in fittings for electric lights.** John Smallwood, 33, Southampton-buildings, Chancery-lane, London.

MAY 11.

8894. **A type-writing electric telegraph.** Alfred Edwin Hardaker, 2, Beech-terrace, Beech-street, Fairfield, Liverpool.

8898. **Improvement in electric contact-making device.** George Keith Buller Elphinstone, 86, Canonbury-road, London.

8956. **Improvements in or relating to electro-medical belts and appliances.** Alexander Knox, 18, Buckingham-street, Strand, London.

MAY 12.

8986. **Improvements in mains and conduits for electric cables, and in collars and connections for same.** Dan Rylands, Shepcote, Stairfoot, Barnsley.

8987. **Improvements in secondary batteries and accumulators.** Pierre Germain, 98, rue d'Assas, Paris. (Date applied for under Patents Act 1883, sec. 103; February 23, 1892, being date of application in France.)

9002. **Improvements in connectors and like appliances for electric lighting and kindred purposes.** William Macpherson and Arthur James Howes, 11, Furnival-street, Holborn, London.

9014. **Improvements in storage batteries.** Herbert John Allison, 52, Chancery-lane, London. (Patrick Kennedy and Charles Joseph Diss, United States.)

9036. **Improvements in electrical accumulators.** Richard Bradley, Noël Lewis Pocock, and William Brown, 4, Highgate-rise, London.

9056. **Improvement in means for electrically giving reciprocating motion.** Henry Squarebrigs McKay, 4, South-street, Finsbury, London. (Complete specification.)

MAY 13.

9108. **Improvements in or connected with electric batteries.** Charles Percy Shrewsbury and John Laskey Dobell, 57, Chancery-lane, London.

9110. **Improvements in microphones or transmitters.** Guillaume Arnaud Nussbaum, 29, Ludgate-hill, London.

9132. **Improvements in heating and welding by electricity.** Henry Howard, 24, Southampton-buildings, Chancery-lane, London.

9136. **Improvements in or relating to electric alarms.** Richard Thorn, 9, Warwick-court, Gray's Inn, London.

9142. **Improved combined building block and electric insulation.** Alexander Leslie Fyfe, 22, Southampton-buildings, Chancery-lane, London.

MAY 14.

9147. **Improvements in or connected with electric fittings, such as fuse-blocks, ceiling roses, switches, and the like.** Percy Garniss Ebbutt and John Benjamin Verity, 128, Colmore-row, Birmingham.

9148. **Improvements in swing joints or ceiling connections, for carrying suspended electric light fittings, or combined electric light and gas fittings.** Percy Garniss Ebbutt and John Benjamin Verity, 128, Colmore-row, Birmingham.

9185. **Improvements in couplings for electric wires.** Alexander Shiels, 70, Wellington-street, Glasgow.

9192. **Improvements in the electrolysis of chloride and other solutions.** Alfred Julius Boult, 323, High Holborn, London. (F. C. Bromley, France.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1887.

6294. **Electrolytic treatment of zinc, etc.** Watt. (Second edition.)

1890.

8534. **Secondary batteries, etc.** Benardos and others. (Second edition.)

1891.

8961. **Measuring electric currents.** Campbell.

9107. **Electric light fittings, etc.** Barnes.

9555. **Electric lamp carbons.** Gwynne.

10425. **Electrically illuminating roundabouts, etc.** Dickinson.

10548. **Winding electrical wires.** Sharrow.

12898. **Electrical deposition of copper.** Parker. (Second edition.)

18421. **Electric lighting system.** Ormes. (Trippe.)

22718. **Heating metals by electricity.** Burton and Angell.

22720. **Heating metal articles by electricity.** Angell.

1892.

4157. **Electric glow lamp shades.** Taylor.

4586. **Magnetic separators for ore, etc.** Thompson and Sanders.

5652. **Electric railway conductors.** Lake. (Thomson-Houston International Electric Company.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2⅜
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5⅝
Metropolitan Electric Supply	—	8⅝
London Electric Supply	5	1
Swan United	3½	4¼
St. James'	—	8
National Telephone	5	4½
Electric Construction	10	6¼
Westminster Electric	—	6 9/16
Liverpool Electric Supply	5	5¼
	3	3⅞

NOTES.

Bath is to have fortnightly reports from its surveyor.

Sevenoaks.—The Sevenoaks provisional order has been revoked.

Crewe.—A resolution has been passed in favour of increased lighting at Crewe.

Hove.—An electric light company for Hove is likely to come before the public shortly.

Dundee.—The contracts for Dundee electric station plant are to be sent in by May 31st.

Killarney is to be lighted by the Brush Company, and £3,000 of 6 per cent. debentures are issued.

Telephone in Russia.—A long-distance telephone line is now opened between Odessa and Nicolaieff.

Barnet.—The arbitration case of Joel *v.* Barnet Vestry is now finished, the decision of the arbitrators being expected shortly.

Bayreuth.—When next the Wagner enthusiasts visit the classic town of Bayreuth, they will find the principal streets lighted by electric light.

Papa is lighted by electricity. We ought, perhaps, to explain that Papa is a town in Hungary, and the contractors are Messrs. Reich and Jellineh, of Vienna.

Telephones in Stockholm.—There are in Stockholm at the present time 6,000 subscribers to the telephone system, paying rates varying from £4. 10s. to £7 a year.

Hull.—As will be seen from their advertisement, the Hull Corporation are inviting tenders for switchboards for their central station. Tenders are to be sent in by June 16.

Dewsbury.—Councillor Whiteley and others of the Dewsbury Lighting Committee have been appointed a subcommittee to visit the electrical exhibition at the Crystal Palace.

Coventry.—The Town Council of Coventry are kindly allowing companies to send in projects gratuitously on the understanding that the work is to be finally put up to public tender.

Manchester.—It is expected that in Manchester the Albert-square will first be lighted by arc lamps, and that in some other parts of the compulsory area the streets will be lighted in the same way.

Newport.—A private professional man has started the ball rolling in Newport in the way of electric lighting. The example will be extensively followed when the Corporation get their powers in order.

Southampton.—A new post office is to be erected at Southampton; also a new free library. There should be electric lighting contracts for these, which are prominent public buildings, in a town with a new central station.

St. Pancras.—It is stated in an evening paper that it has been decided in St. Pancras to supply electricity "at 3d. per unit, which is equivalent to gas at 2s. 6d. to 2s. 9d. per 1,000 cubic feet." We hardly see how it can be done.

Gibraltar.—The lighthouse at Gibraltar is to be refitted by order of the Trinity Brethren. We expect to hear shortly with reference to the lighting of the whole fortress by electric light. The scheme is in the hands of Mr. Preece.

Cable v. Electric Trams.— A similar conversion which has just been completed at St. Louis took place last year at the town of Grand Rapids, where the whole system of cable trams conduit was taken up and the line converted to electric traction.

Vienna.—The International Electric Company of Vienna have more than doubled their supply since last year. They were supplying 33,000 16-c.p. incandescent lamps on April 30th, 1892, as against 15,000 on the same date in 1891.

Windmill Lighting.—The electric installation driven by the windmill at Carwardine's, in the City-road, was supplied and fitted with automatic control by the Wenham Company. We fancy this must be the first windmill installation on a practical scale yet erected in London.

Willenhall.—The Willenhall Local Board is considering the advisability of taking its lighting supply into its own hands, and has appointed a committee to consider the advisability of purchasing the gas works. The committee ought to be fully supplied with information upon electric lighting.

Chiswick.—A proposal has been made by Alderman Hardy, of the Chiswick Local Board, that an electrical expert should be called in to assist the committee which is now considering the tenders for electric lighting, and which have now been before the committee for more than a fortnight.

Chicago.—An electric search-light, 7½ft. high and of 25,000 c.p., is being made for the World's Fair Exhibition at Chicago, and it is expected this light will be visible for 60 miles. A telephone exchange, with 600 subscribers, being erected, and long-distance communication will be made with New York, Philadelphia, and other towns.

Leeds.—The transfer of the site for the Yorkshire House-to-House Electricity Company's central supply station in Aire-street, Leeds, was completed last week. The tenders for machinery and underground mains were sent in on Thursday. It is understood that the works will be proceeded with at once, as soon as the tenders are accepted.

Exeter.—The consideration of the Exeter surveyor's report (given elsewhere) is adjourned till June 8 until a reply is received from the gas company, and in the meanwhile the electric light company will be communicated with as to hours of lighting. The committee are further instructed to consider the question of lighting the open spaces by electric light.

Eston.—The surveyor, Mr. Stainthorpe, has reported to the Local Board that he has considered the probable cost of lighting the streets of Grangetown with the electric light, as compared with the present system, and estimated the cost of the necessary plant to be £1,550 for an installation giving 4,080 c.p. The working expenses would be about £300 a year.

British Association.—The sixty-second B. A. meeting, which is to take place at Edinburgh, will commence on Wednesday, August 3. Invitation circulars are now being sent out, and communications should be made to Prof. A. W. Rücker, at Burlington House, London, W. The president-elect is Sir Archibald Geikie, LL.D., etc., and the president of the Physical Section is Prof. A. Schuster, F.R.S.

Wigan.—"Hotspur," in the *Blackpool Herald*, has an amusing interview with Mr. G. Stephen Corlett, of the Corlett Engineering Company, on electric lighting and things in general. Mr. Corlett mentioned that his firm had tendered for the Blackpool lighting, advocating mixed arc and incandescent lamps, and gave much other information which filled the genial "Hotspur" brim full with technicalities.

Changing the Badge.—The National Electric Light Association, whose proceedings provide so many excellent papers, have as badge the well-known formula $C = \frac{E}{R}$. In view of the Thomson-Houston-Edison combination and the proposed amalgamation of the Edison Association with the National, it is suggested that the badge ought now to be $E = \frac{T}{H}$.

Lightning.—At Derby one of the pinnacles of St. Werburgh's Church was struck by lightning on Wednesday, and a great hole was knocked in the roof. There was no lightning conductor. At the foundry of Messrs. Russell and Son the lightning struck a flagpole, descended to the storeroom, and tore off one side of the gas-meter, 3ft. 6in. in diameter and 1in. thick, fortunately without setting fire to the gas.

Books Received.—We have received "Electric Lighting for Marine Engineers; or, How to Light a Ship by Electric Light, and How to Keep the Apparatus in Order," with 134 illustrations; by Sydney F. Walker. Tower Publishing Company, 91, Minories, E. We are also in receipt of the fifth edition of that well-known book, "Electrical Instrument Making for Amateurs," by S. R. Bottone. (Whittaker and Co.)

Western Australia.—Perth, the capital of Western Australia, is to be lighted by electricity. A tender for the necessary work was lately submitted to the Perth authorities by the Western Australian Electric Light Company, and the whole proposal has now been reported upon favourably by Mr. W. J. Hancock, the superintendent of telegraphs in the colony. The tender for dynamos, lamps, and fittings were sent in through Messrs. Crompton and Co.'s Sydney house.

Tempering by Electricity.—According to a French paper, electricity is in successful use at the gun factory at St. Etienne for tempering gun springs. The latter consist of steel wire, which is wound spirally, and a current of 23 amperes at 45 volts is passed through it. Rapid heating results, and when the required temperature has been reached the circuit is broken and the spring is let fall into a trough of water. One workman, it is stated, can temper 2,400 springs per day by this method.

Transmission of Power.—Mr. D. Selby Bigge, of Mosley, Newcastle, has forwarded to us a copy of an important paper on "The Practical Transmission of Power by Means of Electricity," read by him before the North of England Institute of Mining and Mechanical Engineers. It contains a description of Lord Durham's electric mining installation, and there are several tables showing the various efficiences of electrical transmission of power for pumping, hauling, and other purposes.

Thomson Meter.—The 10,000f. award for the Thomson meter at Paris has been returned by Prof. Thomson to be devoted to public interests. It is stated in the French technical press that, owing to this award, the Thomson meter is fast beating the Frager and other meters out of the field. It is also stated, however, that it is quite easy to falsify the records of the meter by manœuvring an ordinary magnet on the outside. This, it is to be supposed, is with a meter not furnished with an iron case.

Royal Military Tournament.—The electric lighting of the Royal box and the officers' quarters and offices at the Royal Military Tournament has been carried out by Messrs. Woodhouse and Rawson, United—Epstein accumulators of the "country house or private installation" type being used as a reserve. Two balloon lights, and also "Scott's signalling lantern," by which Morse signals are flashed, have also been provided by this company. The whole of this work was carried out in three days.

Dundee.—When, at the last meeting of the Dundee Gas Commission, it was decided to advertise for tenders for electric plant, a small committee was also appointed, consisting of Lord Provost Mathewson, Lord Dean of Guild M'Grady, Ex-Provost Brownlee, Ex-Provost Ballingall, and Messrs. Foggie, Cargill, White, and Bruce, to consider further as to details and to report. This committee will supervise the erection of the central station.

Hammersmith.—The West London Electric Lighting Company have written to the Hammersmith Vestry notifying that the conditions of the consent of the Vestry to the provisional order were so onerous that they decline to proceed further with the matter. They had deposited £300 with the Vestry and have asked for its return. The Vestry, however, is considering as to whether all the money shall be paid back, and the matter will be reported upon and discussed at the meeting this day week.

Hanley.—As will be seen by their advertisement, the Corporation of Hanley invite tenders for the execution of works required for the supply of electricity within the borough, in accordance with the Hanley Electric Lighting Order, 1891. Plans and particulars may be obtained from Mr. Joseph Lobley, M.Inst.C.E., borough engineer, on payment of two guineas, which sum will be returned on receipt of a bona fide tender within the specified time. Tenders are to be sent in by Monday, 20th June.

Midland Railway.—The Midland Railway Company have for some time past been engaged in extensive additions and alterations to their Hunslet goods station at Leeds. The total area is nearly eight acres, and the cost of outlay is about £170,000. The interior is being fitted up in a most complete manner, and will be lighted by electricity. The electric power-house stands next to the hydraulic-house. The entire electric plant has been furnished and erected by Messrs. Fowler and Co., of Leeds.

Glasgow Tenders.—The following is the list of accepted tenders for the Glasgow central station: boilers, Lindsay, Burnett, and Co., £4,700; engines, dynamos, and steam connections, Latimer Clark, Muirhead, and Co., £12,918; troughs and service-boxes, R. McLaren and Co., rate per ton; laying ditto, Wm. Pollock, per yard; insulators, Jas. Stiff and Sons, per dozen; copper strip, Elliott Metal Company, per pound; cable, Henley's Telegraph Company and India Rubber Company, per yard; secondary batteries, Crompton-Howell Company, £2,600.

The Faure Patent in Germany.—The Supreme Court of Appeal at Leipsig has just delivered a judgment confirming the decision of the Patent Office at Berlin and establishing the validity of the Faure patent. Several of the secondary battery manufacturers in Germany had entered process in the Patent Office seeking to have the Faure patent declared invalid on the ground that its main features had been anticipated. This contention has now been finally disposed of in favour of the Faure patent. This decision will have an important effect on the secondary battery business in Germany.

London Subways.—In the Select Committee of the House of Commons on Wednesday, the London County Council's (Subways) Bill was under consideration. Lord Crawford, Sir F. Bramwell, and others gave evidence with reference to the objections of the electric lighting companies to be subject to the County Council instead of the Board of Trade. The committee held that the companies had made out their case, and decided that they should be exempted from the provisions of the Bill unless the clause was so altered as to make the Board of Trade the con-

trolling authority. Counsel undertook to alter the clause to this effect.

Azores Cable.—The trouble over the Lisbon-Azores cable tender is not yet settled. Only one tender—that from the French company—was made on the date required (Wednesday). This company accepts all conditions laid down, together with pecuniary advantages. It has the exclusive right for five years from the French Government to lay cables between France, Portugal, and the French colonies. The repudiation of the advantageous terms of the British company, it is said, may cause great loss, and the British Government have interfered, but it is believed the company will withdraw their claims.

Oxford.—The Oxford central electric station is situated close to the railway and river, some little distance from the colleges. The machinery is being got into place, three triple-expansion vertical engines are practically fitted and ready, though the steam piping is not yet connected. The three boilers, of the tubular locomotive type, are fitted with Green's economiser. The foundation rails for the dynamos are in place, and the dynamos will be shortly erected. The sub-station system, with continuous-current motor-transformers, are to be used, it will be remembered, at Oxford. Silvertown cables are being used for the feeders, and Callender cables for the mains.

Electric Launch.—A new electric launch, "Myiomi," left Chiswick on Sunday last for Windsor. Her dimensions are as follows: length 35ft., beam 5ft. 8in., draught aft 18in. The boat was designed and moulded by Mr. W. S. Sargeant, of Strand-on-the-Green, Chiswick, for Captain Homfray, of the Horse Guards, whilst manager last year for Messrs. Woodhouse and Rawson, and has been built by them. The hull is constructed of mild steel, and is fitted with a very handsome teak cabin. The electrical power consists of 40 E.P.S. accumulators with high-speed propeller connected up direct with the armature shaft, running at about 650 revolutions per minute.

Bradford Firm.—We are pleased to notice the continual increase in the number of electrical firms in the provinces, which show a healthy state of electrical trade. The Wray Electrical Engineering Company is the name of a new company just formed at Soho Electrical Works, Thornton-road, Bradford. They have commenced business with the manufacture of dynamos, arc lamps, and so forth, Mr. Cecil Wray taking the management of the business. The company have several installations in progress, including the lighting of Rufford Lodge, Dewsbury, for C. B. Crawshaw, Esq. The company manufacture their own type of dynamo, which is known as the "Soho," and seems to be a well-built machine.

Purdue Electrical Laboratory.—The town of Purdue, at Lafayette, Indiana, is very completely furnished with apparatus. It has a 120-h.p. triple-expansion engine, with boilers; and a full-size railway locomotive is suspended in the air, so fitted that all the conditions of actual running can be obtained and tests taken. There is a gas engine, turbines, and apparatus for measuring the flow of water. In the electrical laboratory is an original Gramme machine, besides Thomson-Houston, Brush, Edison, and other dynamos, a set of Thomson ampere balances, a Kew magnetometer, and other fine instruments. Prof. A. P. Carman holds the chair of applied electricity. There are in all 640 students in attendance at Purdue University.

Blackburn.—There is a sudden change in the attitude of the Blackburn Town Council on the electric light question, and the Corporation will, it is understood, themselves undertake the supply. The Gas Sub-Committee have finally resolved to recommend the Town Council to proceed at once with the project for supplying electricity for lighting purposes and motive power in the centre of the borough, in accordance with the scheme which has been under their consideration for some time. It is said that the sub-committee were largely influenced in their decision by a remarkable increase in the number of applications for the light within the last few days, and the fact which has been borne in upon them that it will be possible to supply electricity for the working of light machinery in many directions.

New Zealand.—We are always pleased to have a line from electrical friends in the colonies, where we are sure electricity has a fine field before it. Advices constantly show that progress is being made. Mr. R. H. Postlethwaite, writing to us from Dunedin, New Zealand, mentions that he and his partner, Mr. Stevenson, have enlarged their business, and are undertaking both electrical and general engineering, under the name of the New Zealand Engineering and Electrical Company. They have taken the sole agency for Crompton's machinery, and have already introduced a considerable number of their dynamos. They have installed arc lighting plant at three gold mines, incandescent lighting plant at four mills and two meat-freezing works, and are now erecting in the north island plant to light a private house, with all the farm buildings, and also to transmit the power to the woolshed to drive the shearing machines.

Strand Electricity Supply.—The Gatti central electric station, after having been turned into the Electricity Supply Corporation, Limited, with a share capital of £150,000 in £5 shares, of which £50,000 has been issued, has now come forward for subscriptions for another £100,000, and £70,000 of 5 per cent. debentures. The company are already supplying 22,000-8 c.p. lamps. The existing plant is capable of supplying current for 40,000 8-c.p. lamps fitted, and with extra boiler capacity up to 60,000 lamps. The three-wire Callender-Webber mains are already 16 miles in length, capable of carrying current for 40,000 8-c.p. lamps, and can be easily increased to a capacity of 75,000 lamps wired. The company supply the Lyceum, Garrick, Adelphi, and Trafalgar theatres, the Tivoli and Hungerford music halls, London County Council offices, St. Martin's Town Hall, besides the Hotel Metropole, Grand, Charing Cross, Morley's, Haxell's, and many other important buildings.

Society of Arts Medal.—The Albert Medal of the Society of Arts for the present year has been awarded to Mr. Thomas Alva Edison, in consideration of the distinguished services rendered by him to the progress of electric lighting, telegraphy, and the telephone. This medal was instituted in 1862 as a memorial of the Prince Consort, for 18 years the president of the society, and is awarded annually for distinguished merit in promoting arts, manufactures, or commerce. It was first awarded in 1864 to Sir Rowland Hill, and amongst the distinguished men of science who have since received it have been Faraday, Whitworth, Liebig, Lesseps, Bessemer, Siemens, Armstrong, Thompson, Joule, Hofmann, and Helmholtz. In 1887 it was presented to her Majesty on the occasion of her jubilee. This is the second occasion on which it has been awarded to an American. In 1884 it was given to Captain Eads in recognition principally of his great engineering works at the mouth of the Mississippi.

Henley's.—The recent description of Messrs. Siemens's works in the *Manufacturers' Engineering and Export Journal*, has been followed in the May number with a similar article on W. T. Henley's Telegraph Works Company, of North Woolwich, and 27, Martin's-lane, Cannon-street. Mr. W. T. Henley, says the article, was born in 1814 at Midhurst.

Destined for a leather-dresser, he gave up this, taught himself the use of lathes and tools, and took to making philosophical instruments, which he sold at a neighbouring chemist's. At the age of 24 he was noticed by Prof. Wheatstone, and eventually invented a magnetic telegraph, which he sold to a company for £68,000. He built his famous works, 12 acres in extent, in 1853, his first cable being that from India to Ceylon, laid in 1857. The article describes the cables manufactured since that time, and gives illustration of the Henley works, with detailed reproductions of the guttapercha shop, the callendering mills, braiding shops, guttapercha-covering shops, core-testing tanks, fitters' shop, stranding and cable-making shop, beside an interesting view of the cable-tank. The article is certainly well descriptive of the Henley cable works, and it seems to be intended to follow the series by others.

The Whitehall Club.—The members—and especially the electrical members—of this club and a number of their guests inspected the Electrical Exhibition at the Crystal Palace on Wednesday last. Messrs. Swinburne and Co.; Messrs. Laing, Wharton, and Down; Messrs. Siemens; and Messrs. Crompton and Co. invited the visitors to witness special experiments, which proved fascinating and instructive. After the inspection of the exhibits a merry company sat down to dinner in the Garden Hall. Unfortunately the evening was warm, the diners many, and the walls inexpansible, otherwise no breath of reproach could have been heard. However, electrical engineers are used to crowding, and most of them rather enjoyed the perfect contact, than otherwise. Genial W. H. Preece presided, and all the arrangements were admirably carried out by the ubiquitous, energetic, and unwearied trio forming the committee—Messrs. Albright, Killingworth Hedges, and P. Sellon. A most enjoyable evening was passed; the toasts were not too numerous, the speeches were witty and wise, and ultimately the company broke up feeling there was no industry like the electrical industry, and no good-fellowship like that of the Electrical Section of the Whitehall Club.

Waterford.—The condition of the electric lighting question at Waterford does not seem to have yet improved or reached its crisis. Captain Toole tried to raise the matter at last week's meeting of the Council, but was eventually ruled out of order, as the Council had been summoned to discuss the water rate. Alderman Toole suggested that the town clerk should correspond with the electrical engineer of Dublin as to the probable cost of electric light in Waterford if the town took up the supply. This he thought would not commit them to any expense. Mr. Smith objected, and the Mayor remarked he could not put the proposition. Mr. Cadogan said they had a lighting committee who had the matter in such a stage as to meet Mr. Wharton on the subject, but had not yet come to a definite point. Mr. Smith stated they had already procured Mr. Manville's report to the Lord Mayor of Dublin, and there was no difficulty of judging what the cost would be to Waterford. It was not fair to take the question out of the committee's hands and spring the report of an electrical engineer upon them. It was stated that the committee would report at the next meeting, the Mayor remarking that they would be glad of any suggestion from Alderman Toole. The matter was then dropped.

Chamber of Commerce.—The annual meeting of the Electrical Section of the Chamber of Commerce will be held at Botolph House, Eastcheap, to-day (Friday) at 2.30 p.m. The agenda contains the following items: Chairman's report; election of chairman and deputy-chairman; to consider the desirability or otherwise of the section following the precedent of other sections of the Chamber in convening the whole of the membership of the section to all future meetings, appointing special committees to deal with special subjects; the attitude of the electrical trade towards the Chicago Exhibition; telephone question; the attitude of the section towards the Parliamentary Committee who are to consider the whole question of electric railways in London; the action taken by the Chamber in reference to the question of overhead wires, and to consider the reply from the President of the Board of Trade; by-laws of the County Council in reference to overhead wires; electrical communication on the coasts; commercial education; to consider whether the section would be prepared to support the commercial education scheme of the Chamber by subscribing annually for a prize or prizes to be awarded in the name of the section; co-operation of the section with the new Mining Section of the Chamber; proposed addresses and other matters. As the meeting is an important one, a full attendance of members is invited.

Riveting by Electricity.—The new method of riveting by electricity which has been put to a practical test in Pittsburg, Pennsylvania, is stated to be a remarkable success. The apparatus comprises a transformer, the primary of which is formed of a heavy copper bar laid parallel to a cell of fine wire, and over the two are clamped two angular segments of iron, forming when united a completed iron shell which is claimed to increase the efficiency of conversion. The structure creates a current of great volume in the copper bar. In the end of this bar is mounted an anvil provided with a regulation screw for moving it up or down, and a follower provided with a screw. In the circuit of a primary is placed a choking coil provided with a regulating switch for cutting in more or less of the coil by which the strength of the current induced in the secondary may be controlled. The bars or pieces of metal are placed upon the anvil, and the rivet dropped in place, the anvil being then screwed up until the plates of metal are firmly held between it and the two insulating legs secured to the upper limb of the copper bar. The face of the bar is covered with insulating material, except at a central point, where it is left bare, and forced against the rivet the latter establishes connection from the upper limb of the primary bar to the lower limb, the current developing sufficient heat to make an upsetting of the rivet shank very easy under the pressure of the screw.

Croydon.—Mr. Perren Maycock, writing to the *Croydon Advertiser*, says: "It will be a matter for surprise and interest to many to know that there are 11 installations of the electric light in the borough of Croydon, representing a total of nine arc and about 733 incandescent lamps. Subjoined are particulars of these installations: R. W. Thomas and Co., Parchmore-road, Thornton Heath, May, 1884, 60 incandescent; W. R. Dell and Son, Factory-lane, Pitlake, September, 1885, eight arc, 100 incandescent; Mr. J. W. Prince, Addiscombe-road, March, 1887, 66 incandescent; Mr. Silvester, Wellesley-road, October, 1888, four incandescent (in occasional use); Mr. F. W. Radford, S. Park Hill-road, September, 1890, 50 incandescent; Mr. Newman, London-road, November, 1890, 83 incandescent; Mr. Wilson, North End, November, 1891, one arc, 40 incandescent, February, 1892; Mr. Docking, George-street, December, 1891, 30 incandescent; Mr. Lloyd, Shirley-hurst, April, 1892; C. Brown and Co., Waddon Flour Mills, will run in June about 200 incandescent; Messrs. J. and T. H. Wallis, Wandle Four Mills, 1891, about 100 incandescent. The fact that most of these installations have been put down since the beginning of 1890, while the first dates as far back as 1884, shows how rapidly the light is now spreading. Users of steam and gas engines are

gradually waking up to the knowledge that their spare power may be used for the generation of electrical energy. As a whole, however, Croydon has got the reputation of being a decidedly backward town."

Perpetual Syphon.—Little improvements sometimes make all the difference between the smooth and convenient working of an apparatus and the reverse. In dealing with accumulators, and, indeed, with all kinds of chemical apparatus, there is one small instrument which is often in demand for the handling of acids—namely, a syphon. The principle of the syphon is very old, but there is one objection to the ordinary syphon which rather militates against its extended use, and this is that it has to be exhausted to make it act, and in dealing with acids, to suck a mouthful of the liquid is unpleasant, not to say dangerous. There have been several arrangements of tubes and taps invented to act as self-charging syphons with more or less success, but there is a seemingly apparent obstacle to the invention of a syphon which shall act when once charged without further exhaustion, without the use of taps, and constructed solely of glass. Put the question to a scientist, and it is many chances he would say it is impossible. Nevertheless it is perfectly possible, for when last at Paris we saw such syphons, one of which we believe was shown in the Paris Exposition. It is the patented invention of M. Berlin, director of the Ecole Primaire, rue du Marché, Popincourt, Paris, and consists simply of a bent tube, the ends of which are not open but dip into a concentric closed tube, enclosing the end to the extent of, say, 2in. This outer tube is sealed above to the stem itself, but has a discharge hole a certain distance, say, 1½in. up from the end. The consequence of this arrangement is that the syphon keeps always charged, and it suffices to dip one end in the liquid for the other end at once to begin to discharge.

Glow Lamps.—In the *Journal* of the Institution of Electrical Engineers an abstract is given of some researches by D. Dujon on the life of glow lamps, published in *La Lumière Electrique*, and by Fergusson and Ceuter on the variation of light in glow lamps with current and E.M.F., in the *Elektrotechnische Zeitschrift*. These are experiments carried out in the laboratories of the Cie. Popp at Paris. Four lamps of each type were tested with various E.M.F.'s and curves plotted showing candle-power, current, resistance, and watts per candle-power. Curves are also given of various (unnamed) lamps showing candle-power, and watts per candle-power at normal voltage for their lifetime, the readings being taken daily during the first week, then every two days, and then weekly. The curve for current with E.M.F. varies considerably. In some types it is practically a straight line, in others considerably curved, but in all good lamps it is regular, any breaks in it showing bad manufacture. The straight current line is a sign of a hardy lamp which will stand variations of voltage better than one with a curved current line. The latter, however, with steady E.M.F., will often stand just as well as the former. The candle-power (from 0·8 to 1·2 of the normal voltage) may be with considerable accuracy expressed in terms of the volts by the formula, $C.P. = K (V - a)^n$, where K is a constant depending on the cold resistance, V the volts, and a and n constants, which are given for:

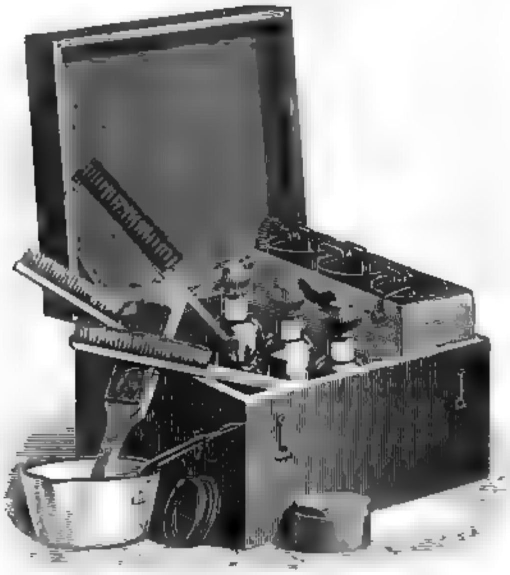
Edison-Swan	110 V ...	$a = 9{\cdot}75$ ...	$n = 6$
Khotinsky	105 V ...	$a = 46$ ...	$n = 3{\cdot}5$
Cie. Française	110 V ...	$a = 9{\cdot}8$ ...	$n = 5{\cdot}7$

The author believes that all new lamps have the same efficiency at the same state of incandescence, assuming the vacuum to be good; the only difference between lamps being their length of life, and the variation of candle-power with running. Curves of candle-power at normal volts are given for three lamps throughout their life. One rises for the first 80 hours, and then rapidly drops, till at last it is only about half the original value; the curve being much like the expansion curve in an indicator diagram, watts per candle-power rising from 2·5 to 5. The rise at the beginning does not always occur. A third curve is unfortunately a rare one. The candle-power falls in a straight line with time, and the watts per candle-power only change from 2·5 to 3·6. Curves are also given showing how life and cost of running vary with watts per candle-power. Messrs. Fergusson and Ceuter's paper deals shortly with the variation of candle-power with E and C. The values of a, b, m, and n are given for certain Edison and Thomson-Houston lamps, for expressing candle-power in terms of $a\,C^m$ and $b\,E^n$. The principal point of interest is that in the modern make of lamps, m and n remain approximately the same as they used to be for older types—viz., 5 and 6 respectively.

The New Telephones for London.—A Press demonstration was given on Wednesday afternoon of the speaking qualities of the instruments proposed to be fitted up in London by the New Telephone Company, of 110, Cannon-street. A set of telephones had been connected to a room over the river at Blackfriars, where a telephone operator was stationed to answer calls and give specimens of the talking quality of the exchange. We had full opportunity of testing the instrument, and found the speaking loud and distinct, with none of the ghostliness and cackle of the telephone we have been made to think normal. We dictated an imaginary mixed order for "grey shirtings, sectional iron standards, and White's Natural History of Selborne,' which was at once and clearly repeated. After a passage had been read out from a book, clearly audible, a recitation from Shelley was given. This was sent out over the room by a funnel to make the hearing general, and while the company present sat down to lunch Dan Godfrey's band played a selection of music that was fully heard over the whole hall—the tongueless instrument sang "When Other Lips," and, of course, the inevitable "Ta-ra-ra." When Mr. A. R. Bennett proposed the toast of "The Queen," the band burst out with the National Anthem, and the health of "The Press ' was rapturously accompanied by "He's a Jolly Good Fellow," which Mr. Bennett remarked, as a curious coincidence, was the same old tune as "Marlbrook s'en va à la Guerre," the present Duke of Marlborough being their leader in a severe though civil war for clear speech. It was stated that the number of promised subscribers had now risen to 2,500, and when the number amounted to 3,000 the directors were determined to go to the public for the necessary capital to carry out the scheme for a perfected telephone system for London. The first 5,000 subscribers, by-the-bye, are to have their service at a reduced rate of twelve guineas a year, instead of fourteen guineas, which is to be the general rate for London subscribers. The new "Mutual" instrument contains a switchbox, a microphone (fitted with rubber bands where vibration is great), a magneto-call, desk for receiving messages, and a simple No. 2 Leclanché cell. The line is a twin wire, No. 18 B.W.G., with additional wire for the operator, who is cut into circuit by a handle-switch on the microphone-box. The operator on the Mann system is always kept listening; the subscriber calls his own and the required number—as "5 on 4,901 "—and is at once connected up. The service on this system in Manchester is most excellent, as proved by the long list of testimonials which the company furnish. A list of intending subscribers in London is also printed by the company, who seem to be working their plans most successfully.

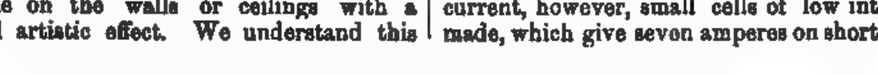
THE CRYSTAL PALACE EXHIBITION.

The great extension of the electric light during the past few years has led to the formation of firms or companies for the special manufacture and wholesale supply of fittings and electrical stores generally apart from heavy plant. These stores supply companies congregated in the City around the classic domains of the Mansion House in the region of wholesale supply houses of other kinds, and the names of some of the older firms are household words amongst the electrical world. One of the more recent of these companies is that trading under the fitting name of **Electric Stores, Limited,** of 51, Cannon-street, and Bow-lane, and this company have an extensive and interesting exhibit at the Crystal Palace Exhibition. They have



Electric Stores Co.'s Plating Set.

a considerable variety of general electric supplies and fittings, such as switches, cut-outs, brackets, and pendants, with a large handsome cut-glass chandelier in the centre of the stand fitted with incandescent lamps, together with other tasteful electroliers. A novelty in the way of casings for electric light wires is certainly worthy the attention of electrical contractors, decorators, architects, and others interested in the artistic handling of electric installations. Instead of the time-honoured whitewood moulded casing, we have long strips of bamboo for this purpose. The bamboo is grooved suitably to receive the wires, and can be cut up into convenient lengths and secured to the surface of the walls, doors, or ceilings in a pleasing manner, or can be easily worked into a kind of Japanese chequered arabesque on the walls or ceilings with a decidedly novel and artistic effect. We understand this



Bamboo Casing for Electric Wires.

bamboo casing has received the approval of the fire office authorities, and in high-class houses could be used with advantage. Another novel exhibit is Major Fowler's patent compensating insulator for telegraph and telephone wires. It is well known that the great trouble with overhead spans is just with those sudden additional stresses that come with a heavy fall of snow or a strong wind. If the insulating supports could be made to yield sufficiently under extra stresses and take up the slack when the strain was over, many wires that now break down would stand perfectly well. The Fowler compensating insulator is an attempt to supply a simple arrangement of this kind. The insulator itself, which may be of any ordinary shape, is made separate from the bracket or iron carrier. This carrier has upon it a strong steel coiled spring which catches in strong projections inside the insulator, and the insulator can be twisted strongly round before the wire is strained, twisted around it and fastened, thus providing a yielding support. When additional strain beyond the normal is experienced the spring yields to a small extent, thus preventing the breakage of the wire, and takes up the slack again when the weight of snow or sudden strain is removed. This insulator should prove exceedingly useful, and we understand it is already in use on the London and Brighton Railway, and in Russia.

The principal exhibit of the Electric Stores Company, however, is their "E.S." dry battery cell, a cell which has proved its usefulness in many departments, as shown by the very large and increasing sale, now amounting to over 5,000 a month. These dry cells are made in all sorts and sizes—from waistcoat-pocket size, for testing, up to large cells of several gallons capacity for giving large currents. The greatest use for the "E.S." dry cells is naturally for

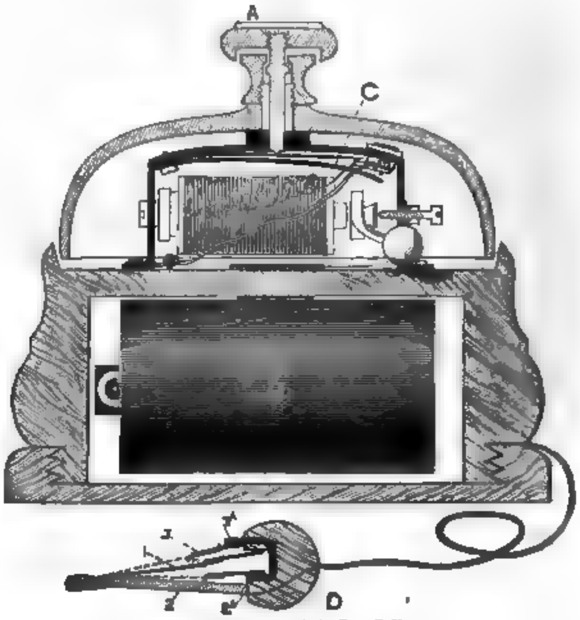
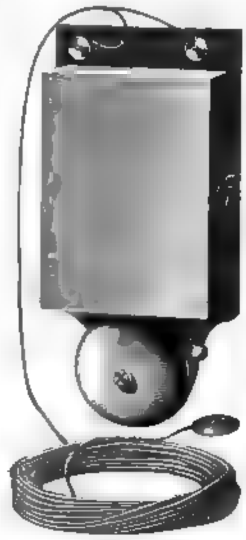


Table Bell, with E.S. Dry Cell.

bell sets, and these are shown in very many shapes in economical and efficient form, separate or combined. The complete bell set consists of battery and bell in one case, with coiled lengths of flexible, and a contact push, exceedingly convenient for bedrooms, or for temporary, as well as permanent use. These cells have good claim to the title "dry." They are very dry, as a section down the centre shows. Their capacity is large, and their lasting power high, as recent tests have served to prove. One of these cells gave current for three hours with a drop of ·5 to ·39 ampere, and then ran for four hours more at one ampere on short-circuit. The large cells give as much as eight amperes constant current at 1·4 volts, and have been supplied for testing and calibrating instruments. For sudden demands of large current, however, small cells of low interior resistance are made, which give seven amperes on short-circuit. It is stated that they can be easily recharged as secondary batteries from a dynamo current when run down. The great advantage is their portability and absolute dryness. Specimens of these cells are shown mounted for various purposes. A watch nightlight is a good example of their use. Four small cells are mounted in a stand on which a watch may be hung, and a flexible contact allows a little five-volt lamp to be lighted from the bedside. If used occasionally for usual requirements, this arrangement will last a year or even more without recharging. Another application is an electric table bell shown in the illustration. A small dry cell is mounted beneath the stand for the table bell, and a press contact at the top acts in the usual way. This little bell has proved a general favourite. Another useful application, by the use of a few cells, drives a small ventilating fan for household use. A special small motor is used for this fan, and with half ampere a 9in. fan can be kept running at a thousand revolutions, or

with one ampere at 3,000 revolutions. The cost of this apparatus is some three pounds or so. The same arrangement is shown driving a sewing machine by dry cells; indeed, the usefulness of these cells is almost unlimited in the smaller applications of electric energy. For instance, the Electric Stores Company have a plating set, in which the necessary current is supplied by their "E.S." dry cells. This we show in the illustration, an extremely useful little set of apparatus not only for an amateur or a student, but in any shop where small jobs of electroplating are required.

Electric Stores Co.'s Dry Battery.



E. S. Electric Bell Set.

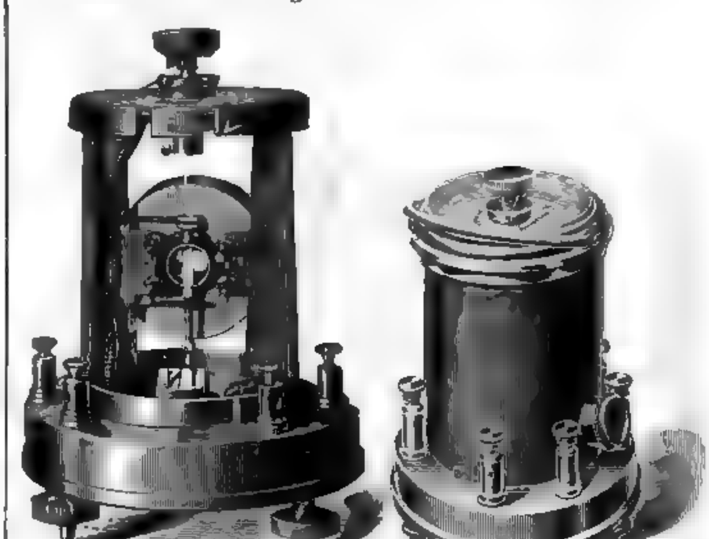
The set comprises the necessary cells, with polishing brushes, scratch brushes, together with acids, solutions for copper, silver, and gold, and the little tools needed for plating work. They also show an electromagnetic clock worked by dry cells. A portable omnibus lamp is supplied with current from the same source.

A further exhibit of the Electric Stores Company we ought to mention is Hoster's electric time-meter with either pendulum or escapement movement. This instrument has been introduced to satisfy the need of some check over the time of burning the light, when a complete electric meter or supply unit measurer is not necessary. It indicates simply the time during which the electric current is being used, and may come into considerable use in certain circumstances where only a few lights are connected—in small houses, flats, or for hotels. In this case the current would be supplied at so much an hour, instead of so much per

Electric Watch Nightlight.

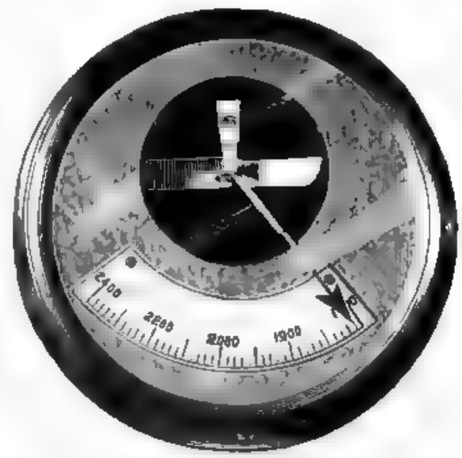
supply unit. We are informed that some of these time-meters have recently been fitted up in a Paris hotel, where the proprietor has adopted the electric light and intends to provide his customers with an easy means of checking the supply of light. The meter has a switch on the outside, which makes or breaks the contact, and sets the clock going or makes it stop. The time is registered on a dial as in an ordinary gas-meter, and the meter being small and compact can be placed in any convenient position. The company also show a large number of their improved make of Edison lampholders, manufactured under license from the Edison-Swan Company — a neat and well-finished holder which they supply to the trade.

One most interesting feature of **Messrs. Swinburne and Co.'s** exhibit is the noted transformer giving nominally 100,000 volts. It is uncertain how much higher this transformer can be run without breaking down, but, as recent experiments have shown, 150,000 volts can be reached. This high-pressure transformer is exhibited working on a condenser, and various experiments which the high pressure make possible are now regularly performed in the Prince's Room. This kind of transformer has been designed for commercial use for testing cables. In order to test a cable



Swinburne's Non-Inductive Wattmeter.

of, say, 0·5 microfarad under 50,000 volts with a frequency of 100, a current of 12½ amperes must be available. A pressure of 50,000 volts, and a current of 12·5 amperes, make 625,000 apparent watts. Messrs. Swinburne and Co. have therefore patented a method by which it is not necessary to use a 625-kilowatt dynamo. A large adjustable choking coil takes or gives nearly the whole 12½ amperes. The dynamo and step-up transformer then supply quite a small current. There is another way of doing the same thing. Suppose the dynamo gives 12·5 amperes and a few volts. One terminal of the dynamo circuit and the outside of the cable are then earthed, or connected together. The other dynamo terminal is connected



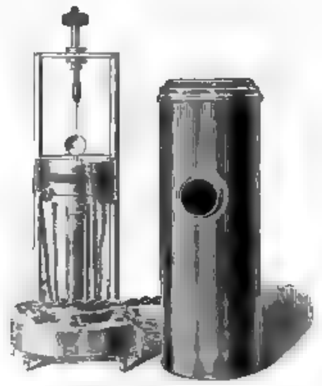
Swinburne's Electrostatic Station Voltmeter.

to the adjustable choking coil, which is in series with the inside of the cable. By this means 50,000 volts can be produced on the insulation of the cable. Messrs. Swinburne and Co. are supplying a large testing plant to one of the leading cable makers for testing a mile of cable at a time under high pressures.

Several alternate-current condensers are also exhibited. One of these is designed for 100,000 volts, for performing experiments with the high-pressure transformer. This condenser is for exhibition purposes, and is not for commercial use. The other condensers are designed to act as compensators, each supplying the idle current of transformers for 40,000 watts. These condensers are also useful

for increasing the plant output when arc lamps are used; and it is proposed to use condensers to displace direct-current machines for exciting alternators. It will surprise many to see how small commercial condensers really are.

Bourne Galvanometer.

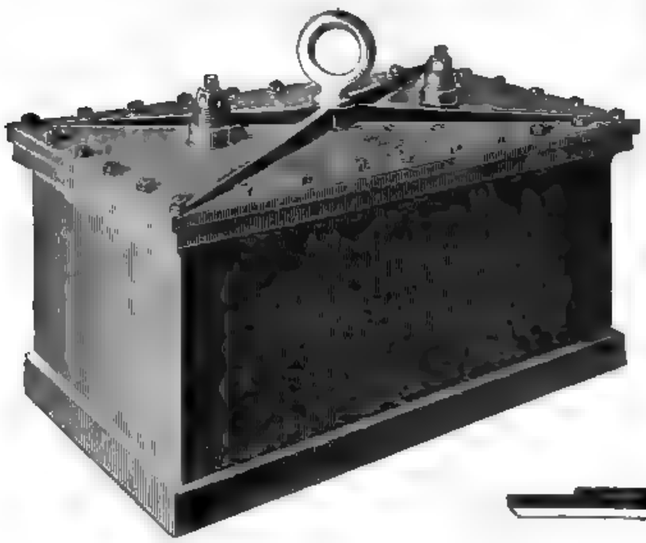


Electrostatic Voltmeter.

Messrs. Swinburne and Co. exhibit some new forms of instruments specially designed for central stations. These all have the same appearance, being made with solid brass cases and bevelled glasses of the usual type. For

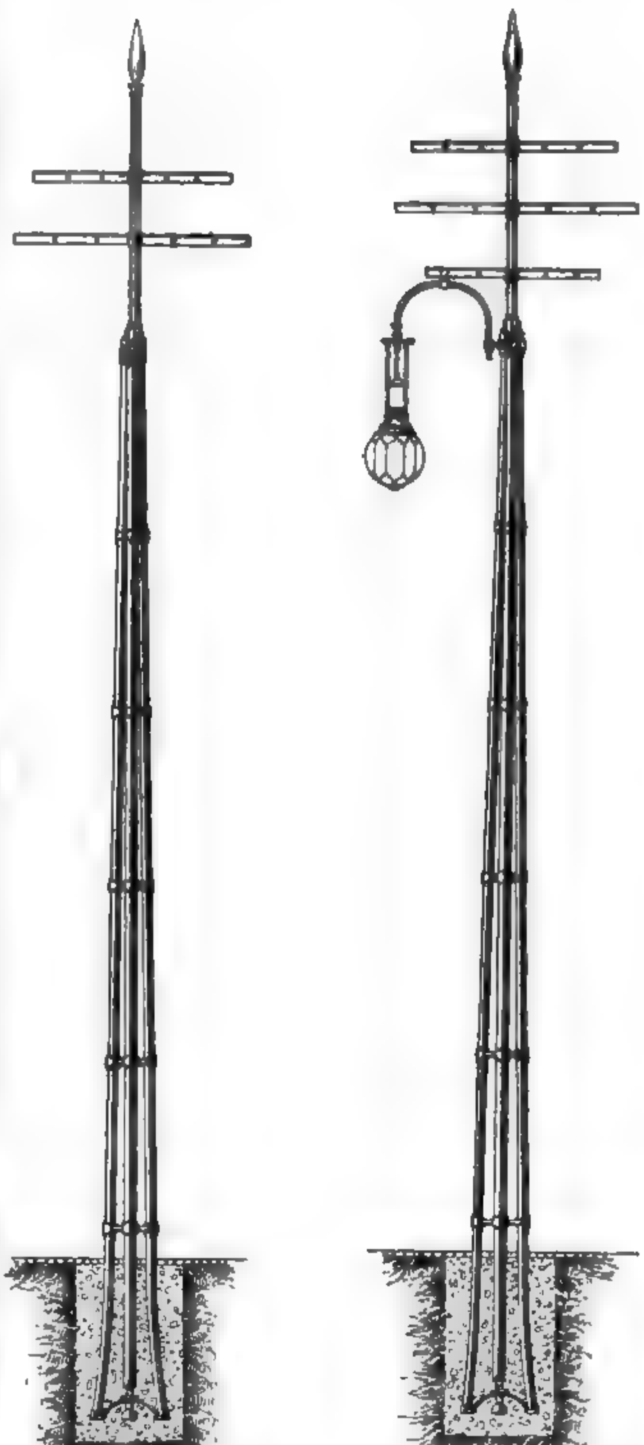
Swinburne and Co.'s Resistance Box.

high pressures, such as used in alternate stations, a special form of electrometer is made. The moving system has two almost semicircular "needles," and the fixed system has four semicircular boxes. The moving system works on tiny



Swinburne and Co.'s Condenser.

friction wheels, which make electric connection. The controlling force is gravity. The half discs of the moving system are really cut in such a way as to give a very open scale between 1,800 and 2,200 volts. It is needless to remark that this form of instrument takes no power and has no temperature errors. This instrument is shown in the illustration. The next instrument, which is much the same in external appearance, is a standard voltmeter for low-pressure stations. This is a moving coil instrument. The moving system again runs on friction wheels, which make the necessary electric connections. The scale in this instrument is spread out for use in stations working between 100 and 110 or between 100 and 130 volts. The other instrument of this type is a station wattmeter for alternate currents. This takes 2,000



Sectional Standards for Arc Lamps and Telegraph Wires.

Sectional Standards Packed for Shipment.

volts and 50 amperes, but reads in watts. It is shown in the figure. Among laboratory instruments this firm exhibits their non-inductive wattmeter. This is an instrument specially designed to give accurate readings in such work as measuring power absorbed by iron in transformers. It

is a dynamometer so designed that the self-induction errors are quite inappreciable. Another form of laboratory instrument for similar purposes is also illustrated. This is a direct-reading electrostatic wattmeter. This instrument can be used either as a wattmeter or as a voltmeter. The particular instruments exhibited were made for some interesting researches on power measurements, on which Dr. Fleming has been engaged.

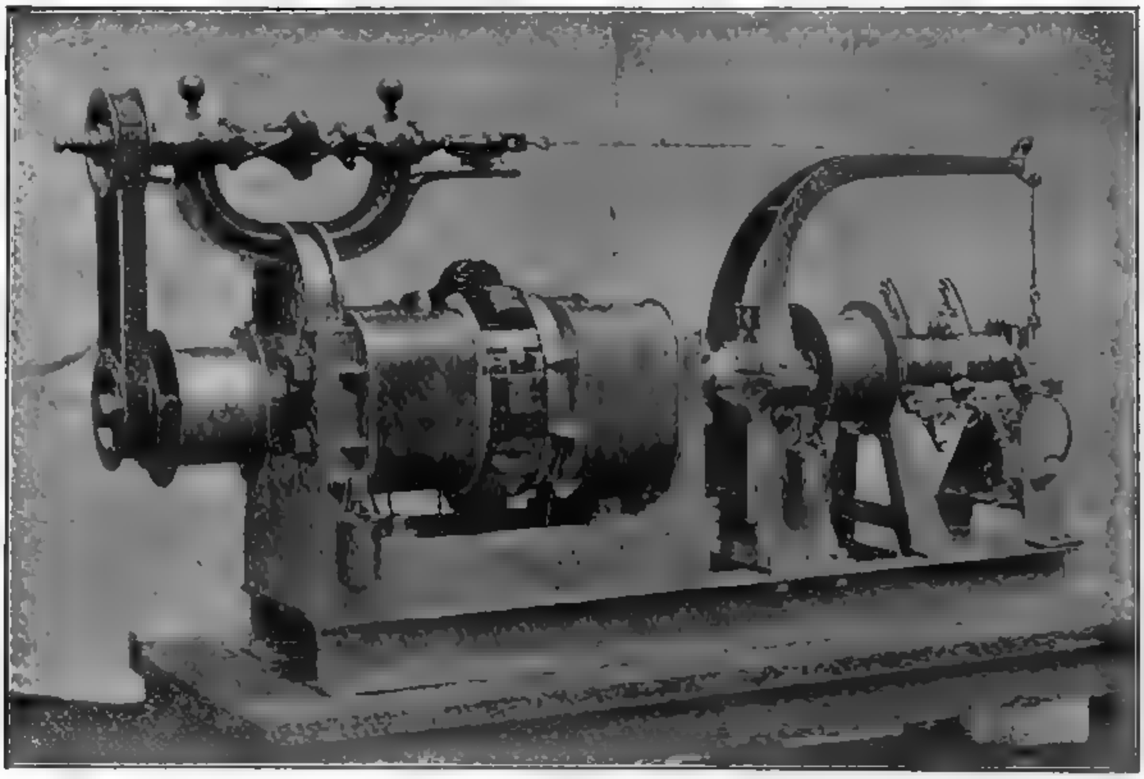
The Bourne form of Thomson reflecting galvanometer is designed to fulfil special requirements. The moving system consists of two vertical needles, so that the instrument is truly astatic, and is not affected by external fields. As to the rest of the design, the object has been to make a really good instrument at a moderate price. The coils are well insulated, being embedded in ebonite, and the coils are supported on corrugated ebonite pillars. The terminals are led through the glass sides of the case. The coils can be taken off and changed easily, and an absurdly simple suspension is used, so that a new fibre can be put in with ease. This instrument has all the advantages of the Deprez instrument, combined with the extra sensitiveness of the Thomson galvanometer.

Messrs. Swinburne also exhibit a resistance-box. This differs from the ordinary form in being worked by switches instead of plugs. The makers hold that the dial form of bridge with many coils and a small but constant number of contacts, is more accurate than a plug with fewer coils and a large and also a varying number of contacts. This form of bridge-box is, of course, much quicker to use.

They also show a reflecting moving-coil galvanometer. Messrs. Swinburne's form is arranged in a small brass case, and has automatic gear, which grips the moving system when galvanometer is lifted.

Perhaps the most interesting instrument is a voltmeter for 100,000 volts A little consideration will show that it is not easy to design an instrument to measure a pressure with a striking distance getting on towards a foot, and a voltmeter in which the active parts were a foot from each other, and a foot from the case in every direction, would be very clumsy. This instrument is on the coaxial cylinder principle. The cylinders are immersed in heavy insulating oil. The active cylinder is connected to one terminal, the wire being carried up through a thick glass tube till it is quite clear of the case. The mechanism and the other two cylinders are attached to the other terminal and are mounted on a glass plate, which is itself mounted on corrugated ebonite pillars. The striking and creeping distances are thus very great.

The Crystal Palace is fairly rich in electric lampposts and standards, from the Brush Company's tubular post, looking like a morsel from the Forth Bridge, the City standards, Messrs. Siemens's tall arc lampposts, and the Tottenham Court-road handsome standards shown by Messrs. Johnson and Phillips. But around in the Machinery-room is an exhibit of standards of rather a different kind by the **Sectional Standards, Limited,** of 38, Lime-street, E.C., which deservedly attracts notice by contractors and engineers on the look out for efficient and cheap posts. These standards are made up of long bars of angle-iron placed in a three-cornered pyramidal manner with a tubular upright, the whole bound stiffly together with suitable bracing-pieces at intervals. This arrangement makes a simple, thoroughly useful, and not unsightly pole or standard for carrying telegraph and telephone wire, or trolley wires for electric railways, and also, perhaps its most suitable service, for carrying overhead arc or incandescent lamps. The great advantage of the sectional standards is apparent at sight: they are cheap, light, and can easily be dismounted and packed together in a small space like a fishing-rod. This adaptability for shipping abroad has already led to a considerable demand for the standards. A catalogue of various designs, with drawings of suitable brackets, is to be issued shortly, and will be sent on application to the company at their London office, or at their works, which are at Jamesbridge, near Wednesbury, Staffordshire. We prophesy a considerable demand for these standards.



The Brush Railway Train-Lighting Plant.

RAILWAY TRAIN LIGHTING PLANT.

A trial view was held at the Brush Company's works at Belvedere-road, Lambeth, last Friday, of a train electric lighting plant, a development and improvement of the Stroudley and Houghton patents. The dynamo, with its governor, is shown in the illustration. It is the final outcome of eight years' experience, during which period the Brush Company have supplied some 60 dynamos for train lighting. The special quality demanded is a constant E.M.F. over a great range of speed. In this dynamo, for a range of speed from 500 to 1,500

revolutions, the E.M.F. only varies 2 per cent. The plant is entirely automatic, only requiring the guard to turn the switch on or off when desired. As the speed rises the governor balls fly out, drawing up the chain which is seen above the commutator. This action both cuts in the charging circuit and also rocks the brushes to the required extent, and prevents sparking.

The plant for the lighting of a train consists of dynamo, cells, and controlling gear, the carriages being usually wired with all lamps parallel. The lights can be run from cells whether the dynamo and train are running or not. The working of the plant is as follows: When the train is at rest the brushes of the dynamo are not on the commutator, and the lamps are supplied with current from the accumulators. The dynamo is driven from the axle of the guard's van by means of a belt. When the train starts (in either direction) the brushes are automatically brought into the correct position on the commutator by the friction, and connections are made which give the field the proper polarity to suit the direction of rotation. When the train attains such a speed as to drive the dynamo at about 500 revolutions per minute, which is the speed giving the necessary E.M.F., a centrifugal governor connects a relay with the cells. This relay allows the cells to excite the fields, and when the latter are fully excited the charging circuit is closed by an automatic switch and charging begins. These operations occur practically instantaneously. At the same time a small resistance is automatically inserted in the lamp circuit to compensate for the difference of E.M.F. across the mains, due to the cells being charged. From this initial charging speed the dynamo maintains a practically constant pressure up to the highest speed attained by the train. A remarkable constancy of E.M.F. is maintained through a long range of speed variation, actual test showing 57 volts at 1,420, 1,000, and 875 revolutions, only dropping to 56 volts at 620 revolutions, and the dynamo being cut out at 520. The action is exceedingly neat, the arrangement most simple, and no flickering is seen on the lamps.

A NEW ELECTRIC LAUNCH.

With a certain section of the public the electric launch is rapidly coming into favour. Not only is it always ready at a minute's notice, but its carrying power and accommodation is much greater than that of a steam launch having the same dimensions, and for those reasons it appears destined to supplant the steam-propelled craft in localities where means are at hand for charging the batteries. An interesting series of trials has just been concluded, on the Clyde, with an electric launch constructed especially for harbour service at Sydney by Messrs. William Denny and Bros., Dumbarton, for Messrs. Sinclair and Geddes, the results of which, together with a description of the vessel, we have much pleasure in placing on record. The launch in question is constructed of wood, and measures 40ft. in length, 7ft. in breadth moulded, and 3ft. 9in. in depth; the normal mean draught of water being 2ft. 5½in. when fully equipped, with 30 passengers on board. The stern, stern-post, and floors are of oak, the keel of English elm, the longitudinals of Canadian elm, while the planking is of pine diagonally laid in two thicknesses, and the bottom is covered with copper. In lieu of the customary deadwood, a bronze bracket is fitted to carry the propeller and rudder. A bronze centreboard is carried, which, when lowered, increases the draught of water by 2ft. With mast, sails, and awning complete she turns the scale at five tons. The storage battery consists of 76 cells of the E.P.S. pattern, arranged along the sides and bottom amidships. Each cell is provided with 11 plates, and the current is conducted to a series-wound motor, supplied by Messrs. King, Brown, and Co., Edinburgh. At full power the working rate of the battery is 40 amperes with a pressure of 152 volts, and the maximum speed can be maintained for three hours or half speed for fully eight hours. The speed guaranteed by the builders was eight statute miles per hour when running light, and to ensure that this should be realised economically, the elements of form embodied in the vessel were selected after conducting a series of trials with models in Messrs. Denny's experimental tank. It was imperative also that the design should possess fair sailing qualities, and the success which attended the recent trials of the vessel speaks loudly in praise of the designers, as both under sail and electricity their original intentions were in every way fully realised.

The builder's trials were carried out over the measured quarter-knot at Dumbarton Castle, when the following results were obtained.

Launch without Mast or Awning up.

With a full complement of passengers.

Mean full draught	2ft. 5½in.
Number of passengers on board	30
Speed in statute miles per hour	7·9
Revolutions of motor	830
Electrical horse-power	6 65

When running light.

Mean full draught	2ft. 3in.
Number of passengers on board	13
Speed in statute miles per hour	8·15
Revolutions of motor	845
Electrical horse-power	6·45

Under sail alone, with the centreboard down, and the propeller idly revolving, the speed over the measured quarter-knot was 6·5 miles per hour in a moderate breeze. With the wind on the quarter the speed registered under sail and electricity was fully nine miles per hour. Every possible care was taken on these trials by specialists to ensure accuracy, and the figures coming from the well-known firm of Messrs. William Denny and Bros., may be considered perfectly reliable. Results equally satisfactory to those already alluded to were afterwards obtained on a prolonged official trial on the Firth of Clyde, in the presence of Messrs. A. B. Brown and A. King, Edinburgh, and Mr. Sinclair, brother of one of the owners.

Our illustrations show the launch first without mast or awning up, and secondly with the auxiliary sails set.

Launch with Sails Set.

ELECTRIC LAMP LADDER PILLARS.

It is not only the City engineer and the chief engineer of the Post Office who have been exercised in their minds over the question of a suitable design of electric lamp pillars for the street lighting. City men generally have criticised for and against the standards now in use, which, if not exceedingly handsome, are generally acknowledged to be "knobby." The foundry companies have lately put their designers on their mettle, and have produced something handsome, efficient, and ingenious.

Messrs. G. Smith and Co., of the Sun Foundry, Glasgow, and 1, Dowgate-hill, E.C., have perfected and patented what seems to us a capital idea for the purpose of ascending as required the tall electric lamp pillars, which will now be seen more and more in the streets of our towns. The invention consists of an easy means of ascending the pillar without the trouble of carrying long ladders, and the method adopted is to have a simple mechanism braced inside the shaft of the pillar. By the tur n of a key or a handle, or the movement of a lever at the outside of base, steps are shot out from the side of the shaft sufficiently far to form a safe and strong ladder. These steps when closed are arranged to be part of the ornament on the lamp-post, or they can be made to form part of a plain or fluted surface. It will be at once seen that several good points are gained by means of this invention. In the first place, the steps of the ladder when closed up forms part of the ornament of the pillar, and this arrangement does away with the necessity of having those hideous-looking knobs or foot-rests which we often see on the present style of electric pillar. In the next place, it saves the workmen the trouble of carrying ladders, or, as is sometimes done, bundles of sticks to fit into holes made in the castings. At the same time it gives a much surer foothold, the ladder being, as it were, part of the main casting, and an additional advantage is that it cannot show on the sides the mud and dirt from the workman's feet. We have had the pleasure of inspecting a model of this new ladder lamppost, and we feel sure that it has a good future before it. We may mention that Messrs. George Smith and Co. are one of the firm who have the contract, and are at present supplying, for the City of London Electric Lighting Company, the new electric light pillars which are to be seen erected along Cheapside, Fenchurch and Leadenhall and other streets. Their posts are in design much more effective than the old ones, and for excellence of casting have been much admired.

THE

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CROWNER'S QUEST.

The late fire at Scott's Supper Rooms and the fatalities connected therewith necessitated a coroner's inquest, during which the cause or causes which led to the fire were investigated. With all due respect to the expert who reported on the coroner's instructions, we think the report was injudicious and altogether misleading. It deals largely, according to the *Times* report, in "might" and "may," in "it is possible" and "I have seen." Anything is possible in a report of this kind. No facts of importance were dealt with; in fact, any record of facts upon which to base a judgment except of this kind, "may" or "might have been," were not forthcoming. Through this report, which "may" have and "possibly" has no shadow of a foundation, the public generally have jumped to the conclusion that the fire was caused by the electric light. The daily papers have been instructing us upon the ways and means of carrying out installations—in the face of the jury's verdict "that the cause of the fire was unknown." Of course, we shall be told that the report of the *Times* is condensed, and that that plague of all speakers—the reporter—has not entirely given the gist of the remarks. Assume that is so, then all we say is, so much the worse for the expert, who upon an occasion of this kind ought not to have left it possible for anyone to mistake his meaning. Either he found direct evidence that the electric wires had caused the fire, or he did not. As we read the report he did not, and then proceeded to give a mass of information upon what "might have been." He then went on to cast an undeserved slur upon one of the most painstaking officials of the fire office—an official whose object is to guard his office from loss. We have always heard that the official errs on the side of being too particular, and yet this expert assumes him to have passed an installation without knowing the position of the wires and their proximity to the gas-pipes. Just fancy an expert saying, "His conclusion was that it was possible, and he would say probable, that the fire was caused by a leakage in the electric wiring, *more especially if* rats and mice had been gnawing at the casing." There is a wonderful incertitude in an *if*. Any stick may be good enough to beat a dog with, but we object to the electric dog being beaten with "may," "if," "possible," and "might have been." We say there was no evidence that the fire was caused by electricity, and that the possibilities and probabilities are altogether against it being so caused. Up to the present time it has, we believe, been a boast of the Phœnix Office that no fire has been traced to an installation carried out under their rules, and yet we are asked in this case to assume the Phœnix to have accepted a risk, and its responsible official to be somewhat ignorant of the kind and manner of wiring. There would be just as much plausibility in assuming the fire to have been caused by the use of tobacco, *if* one of the unfortunate lads had lighted a match, and *if* he had recklessly flung it aside. We should like to know why the firm that carried out the wiring underwent no examination? Much more might be said on the subject, but perhaps it would

be better to remain satisfied with having put forth this objection to experts going out of their way to make surmises when asked to give evidence.

TAUNTON.

According to advices from Taunton, the deal for the electric light installation has practically been settled. We have not cared to enter into the bickering and chaffering between the rival parties—the one having to sell, the other to buy. Mr. Kapp's official report we have given *in extenso*, and it was only natural that this or any other report should be questioned by those who were interested in the sale. He was not called in to act as counsel for the sellers, but as a guide to the buyers, and in such a position was clearly entitled to put his case as clearly as possible, and to state his definite opinions without fear or favour. We were, therefore, intensely surprised at some of the criticisms upon the report—but all's well that ends well. A joint meeting of the directors of the company and the sub-committee of the Town Council has been held, and the figure of nine thousand three hundred pounds agreed upon as the purchase price. It is intended to obtain a provisional order. A few words as to the past may now be permitted. Mr. Massingham has our sincerest sympathy in that his venture has not succeeded up to his most sanguine expectations. He was an early advocate of electricity. He risked his money, he spent his time, and received the applause of us all in pushing forward the Taunton scheme. That scheme roused other people. Many deputations flocked to see it, and without doubt it assisted greatly in the revival of electric work. The station, then, can only be said to have failed as a commercial speculation, and no doubt Mr. Massingham would himself be the first to admit that the financial part, as well perhaps as the apparatus, would differ if the scheme were entered upon *de novo* with our present knowledge. It is to be hoped that the customers which of late hung back with the company will come forward in support of the work, which may now be said to belong to the ratepayers.

THE PROJECTED ELECTRIC RAILWAYS.

The report of the Joint Committee of the House of Lords and the House of Commons has been issued, and is given elsewhere in this issue. As might have been expected, there has really been no real opposition to these schemes. It will be seen that not only does the committee see no reason for postponing these lines, but they contemplate that the construction of these will be followed by the construction of other lines. They conclude also that the evidence submitted proves conclusively the sufficiency and adaptability of electricity as a motive power for these proposed tubular railways. After this report we should imagine that, so far as the Legislature is concerned, the further progress will be pretty plain sailing, and the only rock ahead is that of obtaining capital. Well, when the Metropolitan Railway was proposed there were croakers, and croakers there will be to the end of time. London is so vast, and is growing at such a tremendous rate that additional facilities must constantly be provided for its internal traffic, for its morning and evening exodus, and for country visitors. These facilities cannot well be provided to pass through the streets, and there remains overhead or underground routes. Overhead routes have not found favour—hence it seems conclusive that the means provided must be underground. Steam in this particular direction has had its day. More advantages are to be obtained by the use of electricity, and so electricity it is to be. We should not be surprised to find, when the full text of the minutes and appendix appear, that certain precautionary measures are suggested. These would come with additional force from a committee which includes Lord Kelvin.

OBITUARY.

THE LATE MR. P. WILLANS.

It is with the deepest regret that we have to record the death, through an accident, of Mr. P. Willans, of Messrs. Willans and Robinson. The loss of so able a man is of the nature of a national calamity, rather than a break in the ranks of mechanical or electrical engineers; for the late Mr. Willans had during the past 10 years entered the very front ranks of those engaged in applying steam power to industrial purposes. On Wednesday morning, when driving a new horse from Frimley to the works at Thames Ditton, the horse bolted and Mr. Willans was thrown unfortunately upon a heap of stones, and death was practically instantaneous, although medical aid was quickly obtained. All electrical engineers know how much the firm of Messrs. Willans and Robinson have done in constructing engines to enable dynamos to be directly driven, and it is an undoubted fact that Mr. Willans had a very large share in these improvements. Our personal recollections of the late gentleman extend over almost the whole period of his life subsequent to his connection with electrical matters. In the early eighties, if we remember aright, Mr. Massey and Mr. Crompton worked together with Mr. Willans in various directions, and both those engineers recognised the talent of their colleague and the advantage it would be to the industry if he would provide steam motors for their requirements. How ably he performed what was demanded of him we all know, till Willans's engine and electric governor are to be met with in installations all over the country—nay, all over the world. Quite recently the writer and the late Mr. Willans had an interesting discussion as to the different requirements from mill engines and from electric light engines, Mr. Willans explaining that the problem of a mill engine was a comparatively simple one compared with that of an electric light engine. As we say, we have lost one of the ablest members of the engineering profession, lost him in the high day of his life, when his powers were at their maximum, and when his vast experience would have been of the greatest benefit to the industry.

THE LATE MR. THOMAS PRIME.

The *Birmingham Post*, in announcing the death of Mr. T. Prime, says: "The business which he conducted, first in conjunction with and later in succession to his father, was, we believe, the oldest existing house in the plating trade in Birmingham, having been established as far back as 1818. At the outset, of course, the reputation of the firm was based on the old method of hand plating, but when the discoveries of Mr. John Wright made electro-deposition a success, and when Messrs. Elkington, adding Mr. Wright's discovery to those which they had previously made, took out their famous patents, Messrs. Prime also entered upon the business of electro-plating, in which they subsequently achieved much distinction. Their progress was greatly aided by another Birmingham inven-

tion, that of Mr. J. S. Woolrich, who gave practical application to Faraday's discovery of magneto-electricity. In 1842 Mr. Woolrich patented a machine—a dynamo, in fact—for producing the magnetic currents in such a way as to be applicable to electro-deposition. In the working out of his ideas, Mr. Woolrich received special facilities at Messrs. Prime's plating works, and the younger Mr. Thomas Prime assisted him in reducing the theory to practice, and in the actual construction of the first magneto-electric machine. This machine, which was employed for a long time by Messrs. Prime—who undertook the working of Woolrich's patent—was presented by them a few years ago to the Corporation of Birmingham, and is now deposited in the museum at Aston Hall. Woolrich's form of the dynamo has long since passed out of the practical into the historical stage, but the method embodied in his invention is now in almost universal use as a source of electricity for coating metals, and it is therefore interesting to recall the share which, 50 years ago, Mr. Thomas Prime took in giving the invention a practical application. It may be interesting also to mention that, in 1845, Faraday himself visited Messrs. Primes's works, and saw with great delight the ingenious use which had been made of his discovery of the principle."

The following is Prof. Percy's account of this historical visit: "In 1845 I conducted Mr. and Mrs. Faraday to Mr. Prime's works, where for the first time that great philosopher saw his discovery of the magneto-electric current applied to the deposition of silver. I shall never forget the sparkling delight which he manifested on seeing this result of his purely scientific labours rendered subservient to a beautiful art, and to the advantage of others."

SIR W. THOMSON'S MEASURING INSTRUMENTS.

KILOWATT BALANCE.

These electric watt balances were designed in the first instance to meet the requirements for a standard balance to read up to 10,000 amperes. For this purpose it was not considered advisable to use the ordinary *idiostatic* Thomson balance, on account of the necessarily enormous proportions which the movable beam would have, and the consequent limitation of range due to possible stiffness in the suspending ligament. The instrument, Fig. 1, was therefore designed on the plan of the composite balance, in which the main current passes through heavy copper conductors, while a small current of measured amount is passed through two coils of fine wire at each end of a movable beam in every way similar to that of the Thomson centi-ampere balance. The main conductor is shaped like a double rectangle, as shown in Fig. 2, and the

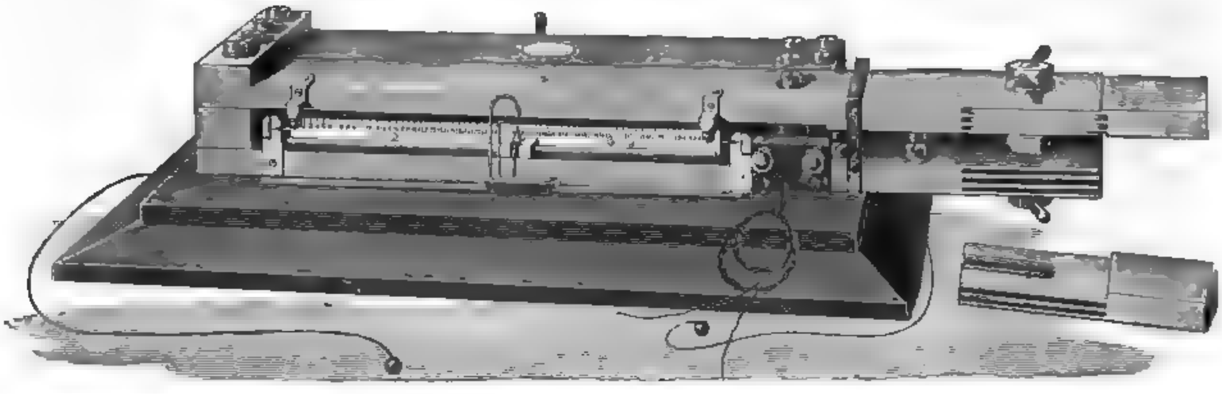


FIG. 1.—Ten Thousand Ampere Balance.

current is conducted in by one electrode round three sides of the top rectangle, then down by a connecting piece at *a* round three sides of the bottom rectangle, and out by the other electrode. The beam, with its movable fine wire coils, is situated between the two rectangles, and its terminals are brought to two binding screws, shown at *b*. The action when the current is passing is the same as in the other Thomson electric balances. The conducting rectangles are each made of a thick copper plate, with a slot about 0·5 cm. wide cut from the right-hand side up to within 9 cm. of the left-hand end.

The instrument is, of course, a self-contained wattmeter, and

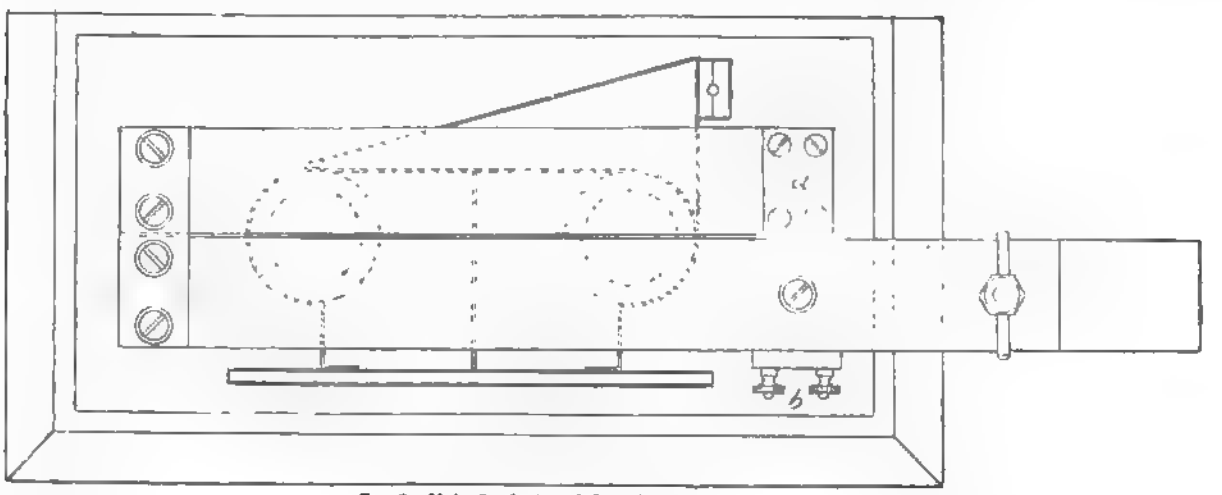


FIG. 2.—Main Conductor of Ten Thousand Ampere Balance.

when it is to be used as such extra resistances are provided for the fine-wire circuit. The resistance of the fine-wire coils is about 10 ohms, and the extra resistances provided are subdivided into coils of 400 ohms each, so as to permit of an adjustment of the instrument's constant from 50 to 2,000 watts per division of the scale. When the instrument is used as a standard ampere balance the current values can be obtained by dividing the watt readings by the E.M.F. if a reliable voltmeter is available; but for very accurate working, it is best to measure the actual current passing through the fine-wire coils on an auxiliary instrument, such as a centi-ampere balance. By this method great sensibility can be obtained, as currents up to one ampere can be used, and so the constant of the instrument can be varied at pleasure from 0·1 ampere to 10 or 20 amperes per division of the scale; and thus a range of measurement from 0·1 to 12,000 amperes is provided. The balance, as described above, is intended for use with continuous current, and it

is evident that an instrument of this kind, if used with alternating current, would require a special constant to suit different periods of alternation.

To suit cases where the testing is either on direct or alternating systems a different type of instrument, called the alternate-current kilowatt-meter, with a stranded main conductor, is made. The instrument is shown in Figs. 3 and 4, and it will be seen that the main conductor is of U-shape, and passes under the movable coils. This conductor is made up of ropes of insulated copper wire, twisted together so as to form a cable with a hollow core.

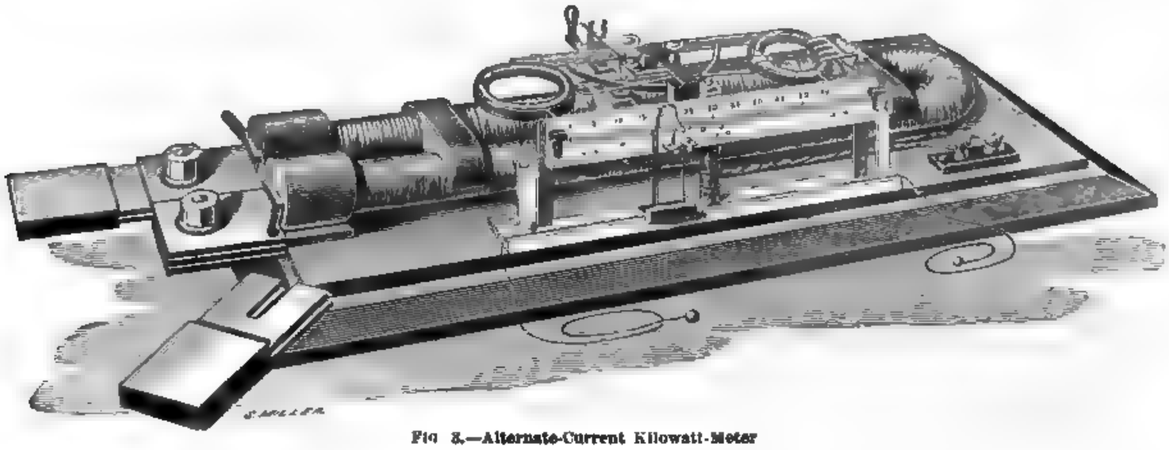


FIG. 3.—Alternate-Current Kilowatt-Meter

In order to correct any effect due to the induction of one arm of the coil upon the other the twisting is done in a very careful manner, so that the strands of the cable which are inside at the position marked *a* are outside at the position *b*. The core of the cable is, as mentioned above, hollow, and brass tubes are passed up each arm of the U as far as the bend. The main object of these tubes is to prevent any deformation in the cable, but they also serve as a means of blowing air through to keep the conductor cool, if it should ever be necessary to use it for much heavier currents than those for which the instrument is primarily intended.

GOLD-LEAF ELECTROSCOPE.

The object of this instrument is to provide a convenient means of measuring approximately differences of potentials above 500 volts in cases where the accuracy of an electrometer is not required, and where its consequent expense would be a serious consideration. Only one narrow gold

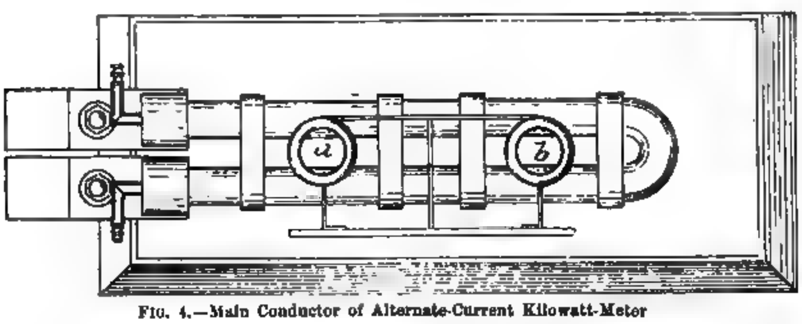


FIG. 4.—Main Conductor of Alternate-Current Kilowatt-Meter

leaf is used, and this is attached by a clamp to a broad plate of brass (Fig. 5). This brass plate is supported on a block of vulcanite from the roof of the case, and has a binding screw attached to it. The case of the instrument—with the exception of the front, which is of glass—is of metal, and the portion below the leaf is cylindrical in shape, so as to obtain from its inductive action a wide range of sensibility. A scale is engraved upon the back of the case, and another is placed in front close to the glass, in order that the deflections of the instrument may be read off without error due to parallax. A hinged frame is attached to the repelling plate, which folds down over the leaf to prevent damage during carriage, and when turned up it acts by repulsion as a guard which effectually prevents the leaf from touching the roof of the case at abnormally high potentials. The instrument may be used as a constant indicator to test the quality of the pressures between earth and each of the two primaries of a high-tension system.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 498.)

A different arrangement used in some of the bulbs constructed is illustrated in Fig. 23. In this instance a non-conductor, *m*, is mounted in a piece of common arc light carbon, so as to project some small distance above the latter. The carbon piece is connected to the leading-in wire passing through a glass stem, which is wrapped with several layers of mica. An aluminium tube, *a*, is employed, as usual, for screening. It is so arranged that it reaches very nearly as high as the carbon, and only the non-conductor, *m*, projects a little above it. The bombardment goes at first against the upper surface of carbon, the lower parts being protected by the aluminium tube. As soon, however, as the non-conductor, *m*, is heated, it is rendered good conducting, and then it becomes the centre of the bombardment, being most exposed to the same. I have also constructed during these experiences many such single-wire bulbs with or without internal electrode, in which the radiant matter was projected against, or focused upon, the body to be rendered incandescent. Fig. 24 illustrates one of the bulbs used. It consists of a spherical globe, L, provided with a long neck, *n*, on the top, for increasing the action in some cases by the application of an external conducting coating. The globe, L, is blown out on the bottom into a very small bulb, *b*, which serves to hold it firmly in a socket, S, of insulating material into which it is cemented. A fine lamp filament, *f*, supported on a wire, *w*, passes through the centre of the globe, L. The filament is rendered incandescent in the middle portion, where the bombardment proceeding from the lower inside surface of the globe is most intense. The lower portion of the globe, so far as the socket, S, reaches, is rendered conducting, either by a tinfoil coating or otherwise, and the external electrode is connected to a terminal of the coil. The arrangement diagrammatically indicated in Fig. 24 was found to be an inferior one when it was desired to render incandescent a filament or button supported in the centre of the globe, but it was convenient when the object was to excite phosphorescence. In many experiments in which bodies of a different kind were mounted in the bulb as, for instance, indicated in Fig. 23, some observations of interest were made. It was found, among other things, that in such cases, no matter where the bombardment began, just as soon as a high temperature was reached there was generally one of the bodies which seemed to take most of the bombardment upon itself, the other, or others, being thereby relieved. This quality appeared to depend principally on the point of fusion, and on the facility with which the body was "evaporated," or, generally

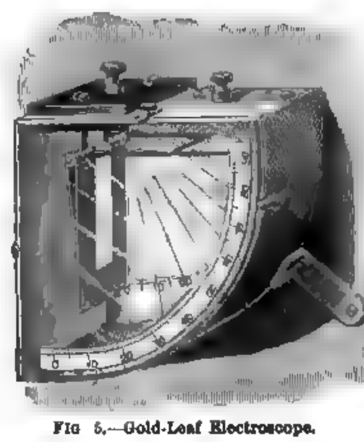


FIG. 5.—Gold-Leaf Electroscope.

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

speaking, disintegrated—meaning by the latter term not only the throwing off of atoms, but likewise of larger lumps. The observation made was in accordance with generally accepted notions. In a highly-exhausted bulb electricity is carried off from the electrode by independent carriers, which are partly the atoms, or molecules, of the residual atmosphere, and partly the atoms, molecules, or lumps thrown off from the electrode. If the electrode is composed of bodies of different character, and if one of these is more easily disintegrated than the others, most of the electricity supplied is carried off from that body, which is then brought to a higher temperature than the others, and this the more, as upon an increase of the temperature the body is still more easily disintegrated.

It seems to me quite probable that a similar process takes place in the bulb even with a homogeneous electrode, and I think it to be the principal cause of the disintegration. There is bound to be some irregularity, even if the surface is highly polished, which, of course, is impossible with most of the refractory bodies employed as electrodes. Assume a point of the electrode gets hotter, instantly most of the discharge passes through that point, and a minute patch is probably fused and evaporated. It is now possible that in consequence of the violent disintegration the spot attacked sinks in temperature, or that a counter-force is created, as in an arc; at any rate the local tearing-off meets with the limitations incident to the experiment, whereupon the same process occurs on another place. To the eye the electrode appears

Fig. 23.—Effect produced by a Ruby Drop.

uniformly brilliant, but there are upon it points, constantly shifting and wandering around, of a temperature far above the mean, and this materially hastens the process of deterioration. That some such thing occurs, at least when the electrode is at a lower temperature, sufficient experimental evidence can be obtained in the following manner: Exhaust a bulb to a very high degree, so that with a fairly high potential the discharge cannot pass—that is, not a luminous one, for a weak invisible discharge occurs always, in all probability. Now raise slowly and carefully the potential, leaving the primary current on no more than for an instant. At a certain point, two, three, or half-a-dozen phosphorescent spots will appear on the globe. These places of the glass are evidently more violently bombarded than others, this being due to the unevenly distributed electric density, necessitated, of course, by sharp projections, or generally speaking, irregularities of the electrode. But the luminous patches are constantly changing in position, which is especially well observable if one manages to produce very few, and this indicates that the configuration of the electrode is rapidly changing. From experiences of this kind I am led to infer that, in order to be most durable, the refractory button in the bulb should be in the form of a sphere, with a highly polished surface. Such a small sphere could be manufactured from a diamond or some other crystal, but a better way would be to fuse, by the employment of extreme degrees of temperature, some oxide—as, for instance, zirconia—into a small drop, and then keep it in the bulb at a temperature somewhat below its point of fusion.

Interesting and useful results can no doubt be reached in the direction of extreme degrees of heat. How can such high temperatures be arrived at? How are the highest degrees of heat reached in nature? By the impact of stars, by high speeds and collisions. In a collision any rate of heat generation may be attained. In a chemical process we are limited. When oxygen and hydrogen combine, they fall, metaphorically speaking, from a definite height. We cannot go very far with a blast, nor by confining heat in a furnace, but in an exhausted bulb we can concentrate any amount of energy upon a minute button. Leaving practicability out of consideration, this, then, would be the means which, in my opinion, would enable us to reach the highest temperature. But a great difficulty, when proceeding in this way, is encountered—namely, in most cases the body is carried off before it can fuse and form a drop. This difficulty exists principally with an oxide such as zirconia, because it cannot be compressed in so hard a cake that it would not be carried off quickly. I endeavoured repeatedly to fuse zirconia, placing it in a cup or arc light carbon as indicated in Fig. 23. It glowed with a most intense light, and the stream of the particles projected out of the carbon cup was of a vivid white; but, whether it was compressed in a cake or made into a paste with carbon, it was carried off before it could be fused. The carbon cup containing the zirconia had to be mounted very low in the neck of a large bulb, as the heating of the glass by the projected particles of the oxide was so rapid that in the first trial the bulb was cracked almost in an instant when the current was turned on. The heating of the glass by the projected particles was found to be always greater when the carbon cup contained a body which was rapidly carried off—I presume because in such cases, with the same potential, higher speeds were reached, and also because, per unit of time, more matter was projected—that is, more particles would strike the glass. The before-mentioned difficulty did not exist, however, when the body mounted in the carbon cup offered great resistance to deterioration. For instance, when an oxide was first fused in an oxygen blast and then mounted in the bulb, it melted very readily into a drop. Generally during the process of fusion magnificent light effects were noted, of which it would be difficult to give an adequate idea. Fig. 23 is intended to illustrate the effect observed with a ruby drop. At first one may see a narrow

Fig. 24.—Bulb without Leading-in Wire, showing Effect of Projected Matter.

funnel of white light projected against the top of the globe, where it produces an irregularly outlined phosphorescent patch. When the point of the ruby fuses the phosphorescence becomes very powerful; but as the atoms are projected with much greater speed from the surface of the drop, soon the glass gets hot and "tired," and now only the outer edge of the patch glows. In this manner an intensely phosphorescent, sharply defined line, *l*, corresponding to the outline of the drop, is produced, which spreads slowly over the globe as the drop gets larger. When the mass begins to boil, small bubbles and cavities are formed, which cause dark-coloured spots to sweep across the globe. The bulb may be turned downwards without fear of the drop falling off, as the mass possesses considerable viscosity.

I may mention here another feature of some interest, which I believe to have noted in the course of these experiments, though the observations do not amount to a certitude. It appeared that under the molecular impact caused by the rapidly-alternating potential the body was fused, and maintained in that state at a lower temperature in a highly-exhausted bulb than was the case at normal pressure and application of heat in the ordinary ways—that is, at least, judging from the quantity of the light emitted.

(To be continued.)

Telephone Currents.—The New York telephone system has 10,000 small dynamos and 30,000 battery cells in use for the microphone currents. The batteries have to be renewed on an average every 11 weeks. One instrument on the long distance lines obtains its current from a gas flame thermopile.

ON THE CHANGES PRODUCED BY MAGNETISATION IN THE LENGTH OF IRON AND OTHER WIRES CARRYING CURRENTS.*

BY SHELFORD BIDWELL, M.A., LL.B., F.R.S.

The changes of length attending the magnetisation of rods or wires of iron and other magnetic metals which were first noticed by Joule† in 1841, and have in recent years formed the subject of many experiments by myself,‡ have been found to be related to several other phenomena of magnetism. Maxwell§ has suggested that they sufficiently account for the twist which is produced in an iron wire when magnetised circularly and longitudinally at the same time. The resultant lines of magnetisation, as he points out, take a spiral form; the iron expands in the direction of the lines of magnetisation, and thus the wire becomes twisted. Prof. G. Wiedemann, however, to whom the discovery of the magnetic twist is due, appears not to be satisfied with this explanation,¶ believing the effect to be caused by unequal molecular friction.

The subject of magnetic twists has been very fully and carefully investigated by Prof. C. G. Knott, and in a paper published last year in the *Transactions* of the Royal Society of Edinburgh (vol. xxxvi., part II., p. 485), he indicates many details in which the phenomena of twist closely correspond with those of elongation and retraction. Assuming their essential identity, and noting that "an increased current along the wire affects the points of vanishing twist in a manner opposite to that in which an increased tension affects it," Prof. Knott is "inclined to conclude that the pure strain effects of these influences are of an opposite character." Now, since the magnetic elongation of an iron wire is known to be diminished by tension, the remark above quoted amounts to a prediction that in an iron wire carrying a current the magnetic elongation would be increased. "We know nothing so far," Prof. Knott observes, "regarding the changes of length when an iron wire carrying a current is subjected to longitudinal magnetising forces," and it was with the object of acquiring some information on this point and testing Prof. Knott's prediction that the experiments described in the present paper were undertaken. The results show that it was amply verified, and thus Maxwell's explanation of the twist receives still further corroboration.

The apparatus used and the methods of observation were the same as those described in my former papers. Each specimen of wire examined was 10 cm. long between the supporting clamps, and the magnetising coil, weighing nearly 3lb., was as usual supported by the wire itself, an arrangement which, for reasons before given, was essential. The indications of the instrument were read to one ten-millionth part of the length of the wire, and the wire was demagnetised by reversals before each single observation.

Experiment 1.—The wire first used was of soft commercial annealed iron, 0·75 mm. in diameter. The changes of length which it exhibited under the influence of magnetising forces gradually increased from 13 to 315 C.G.S. units, are indicated in the second column of Table I., in which the unit is one-millionth of a centimetre or one ten-millionth of the effective length of the wire. The magnetising forces given in the first column are those due to the coil only, no account being taken of the demagnetising effect of the wire. The results are also plotted as a curve in Fig. 1. It will be seen that the maximum increment of length attained in a field of about 40 was 11·5 ten-millionths; the decrement of length in a field of 315 was 22·5, while the original length of the wire was unchanged in a field of 130.

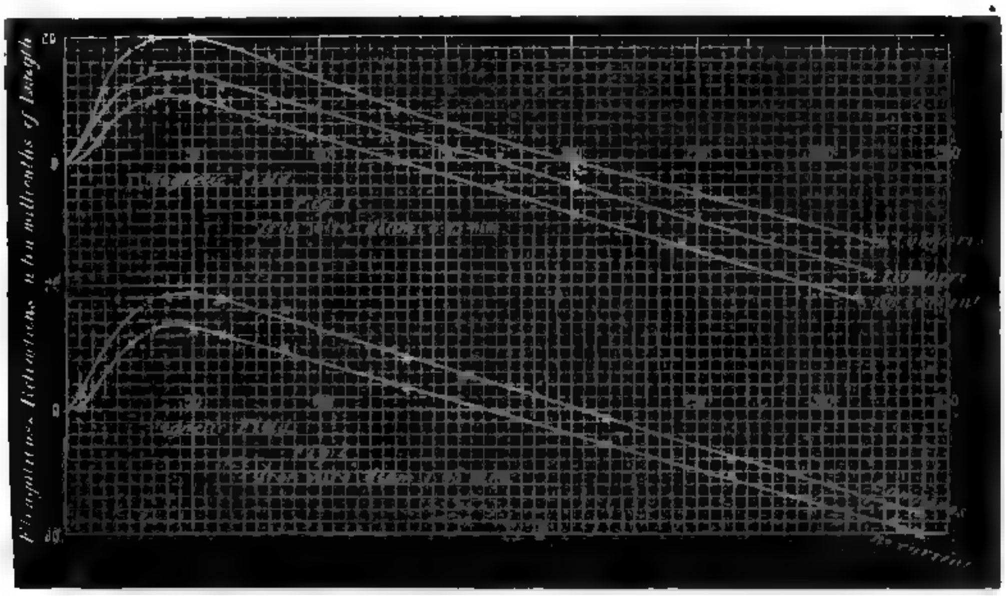


TABLE I.—Iron Wire, diameter 0·75 mm.

Magnetic field due to coil. C.G.S. units.	Elongations in ten-millionths of lengths.		
	With no current through wire.	With 1 ampere through wire.	With 2 amperes through wire.
13	3	7	—
16	6	9	11·5
[illegible]	7·5	12	—
[illegible]	10	14·5	20
40	11·5	14	—
50	10	14	20
61	9·5	12	—
81	6	9·5	16
97	4	8	—
130	0	3·5	8
171	−4	0	—
202	- 9	−4	−1
244	−13·5	—	—
250	—	−9	−5
315	−22·5	—	—
319	—	−18·5	—
323	—	—	−13

Experiment 2.—A current of one ampere was then passed through the wire. The current, which was derived from a Grove cell, was measured by a tangent galvanometer and regulated by a rheostat which had been approximately adjusted on the previous day. As soon as the circuit was closed, the index of the measuring instrument began to move, rapidly at first and afterwards more slowly, in the direction indicating elongation of the iron wire. In about two minutes the index had come to rest again, the number of scale divisions over which it had passed showing that the original length of the wire had increased by 310 ten-millionths. Assuming the coefficient of expansion of the iron to be 122 ten-millionths per degree centigrade, this

* Paper read before the Royal Society on May 19.
† "Joule's Scientific Papers (Phys. Soc.)," pp. 48, 235.
‡ *Phil. Trans.*, vol. 179, A, p. 205; Roy. Soc. *Proc.*, No. 237 (1885), p. 265; No. 242 (1886), p. 109; No. 243 (1886), p. 257; vol. 43, p. 406; vol. 47, p. 469.
§ "Electricity and Magnetism," vol. 2, section 448. ¶ *Phil. Mag.*, July, 1886, p. 50.

elongation denoted a rise of temperature (due to current heating) of about 2·5deg. The experiment described in the last paragraph was then repeated, the several magnetising forces employed being made as nearly as possible the same as before by inserting the same resistances successively in the circuit.* The results appear in the third column of Table I. and in the middle curve of Fig. 1. The latter shows clearly that the maximum elongation had risen from 11·5 to 14·5 ten-millionths, while the decrement in a field of 315 had fallen from 22·5 to about 17·5.

Experiment 3.—The current through the iron wire was then increased, by an alteration of the rheostat, to two amperes. The further elongation of the wire due to the heating effect of the increased current was very nearly 1,000 ten-millionths, corresponding to a rise of temperature of 8·2deg. C. This added to 2·5, the rise due to the current of one ampere, which was passing before, gives 10·7 as the excess of the temperature of the wire carrying two amperes above that of the room. When the index had become steady, which happened in the course of about 2½ minutes, another series of observations was made; but instead of applying all the previously employed magnetising forces in succession, alternate ones were omitted. This was done for the purpose of shortening the experiment, it being thought doubtful whether the Grove cell which supplied current to the iron wire would remain sufficiently constant when giving so strong a current as two amperes. The results of the experiment are contained in the last column of Table I., and in the highest of the curves in Fig. 1. There is again a marked increase of the maximum elonga tion, and decrease of the retraction in a field of 315.

For the sake of easy comparison, the principal results obtained with this wire are collected in Table II.

TABLE II.—Iron Wire, diameter 0·75 mm.

Current through iron wire. Amperes.	Maximum elongation in ten-millionths of length.	Retraction in field of 315 C.G.S. units.	Field in which length is unchanged.
0	11·5	25·5	130
1	14·5	17·5	170
2	20	12	200

Experiment 4.—The previous observations were repeated with another specimen of soft iron wire of greater diameter—viz., 1·05 mm.—no current being at first passed through it. The results appear in the second column of Table III. and in Fig. 2.

TABLE III.—Iron Wire, diameter 1·05 mm.

Magnetic field due to coil C.G.S. units.	Elongation in ten-millionths of length.	
	With no current through wire.	With 2 amperes through wire.
7	1	2·5
16	6·5	11
25	—	15
34	13	18
40	14	18
50	12·5	18·5
62	12	18
87	10	16
134	3·5	8
213	- 5·5	- 1
263	- 10·5	- 8
338	- 20	- 16·5

Experiment 5.—A current of two amperes was passed through the same wire, resulting in an elongation due to heating of 460 ten-millionths, the temperature of the wire being therefore raised about 3·3deg. The former observations were again made, with the results given in the last column of Table III. and in Fig. 2.

It will be seen that with both specimens of iron wire the effect of a current is of just the same general character. It acts oppositely to tension, heightening the curve of elongation instead of lowering it. This action is certainly not due either directly or indirectly to mere current heating. It has been shown that the thinner wire, even when carrying two amperes, was only about 10·7deg. warmer than when no current was passing through it. Such a small rise of temperature would be quite incompetent by itself to account for the effect in question, for the elongation curves of a given specimen of iron have been found to be not sensibly altered when taken under widely different conditions of temperature. Nor would it exert any material influence upon the susceptibility of the iron; and even if it did, the curves would not be affected in the manner observed.

It is hardly worth while attempting to frame an explanation until many more phenomena of the same order have been investigated.

Similar experiments were afterwards made with nickel and cobalt.

Experiment 6.—A nickel wire was used, the diameter of which was 0·65 mm. The retractions which it underwent in fields of gradually increasing strength are given in the second column of Table IV.

TABLE IV.—Nickel Wire, diameter 0·65 mm.

Magnetic field due to coil. C.G.S. units.	Retractions in ten-millionths of length.		
	With no current through wire.	With 1 ampere through wire.	Difference.
12	8	8	0
15	10	11	- 1
19	15	15	0
28	25·5	25	0·5
36	34	33	1
50	50	48	2
69	74	72	2
84	92	92	0
99	113	112	1
119	134	133	1
150	164	162	2
175	178	178	0
209	196	194	2
256	217	215	2
330	241	240	1

Experiment 7.—A current of one ampere was passed through the nickel wire, producing a heat elongation of 340 ten-millionths. Taking the coefficient of expansion as 0·0000129, this implies a rise of temperature of 2·6deg. The retractions of the wire when carrying a current are given in the third column of the table. Remembering that the figures in the second and third columns denote millionths of a centimetre, the close agreement between the two is very remarkable. I have elsewhere* fully described the method of observation adopted, but I may perhaps mention that each number as set down in the table was obtained by the subtraction of two readings, the one taken when there was no current in the magnetising coil, the other when the current was turned on. The former or zero reading was continually changing, owing to small alterations of temperature, the index rarely being absolutely at rest. All the figures were dictated, and when the second experiment was made, I had not seen the results of the first. I may add that the table contains all the observations which were taken in the two experiments.

Though at first inclined to attribute such small discrepancies as exist entirely to observational or instrumental errors and to infer that the current had no influence whatever upon the contraction, I think it appears pretty clearly from a careful inspection of the differences tabulated in the fourth column that this is not actually the case. Four pairs of observations agree exactly; once only the retraction with the current seems to be greater than without it, while in the 10 remaining pairs the retraction is slightly greater without the current than with it. It may, perhaps, be fairly concluded that the current has a real but very small effect in diminishing the retraction. Now I have

* Independent readings of the ampere-meter were taken in the two experiments, and the readings corresponding to the same resistance in both series all agreed within a quarter of a scale division, with the exception of the two last, which showed that the E.M.F. of the battery—seven Grove cells—was slightly increasing, or rather, perhaps, that its internal resistance was diminishing. When two successive readings with the same resistance in circuit differed by no more than a quarter of a scale division (equivalent to 3·125 units of magnetising force), the mean of the two readings was taken as giving the true current.

* *Phil. Trans.*, vol. clxxix., A, p. 218.

before remarked that the degree of retraction which nickel undergoes when magnetised is materially affected by comparatively small changes of temperature; the retraction of the same specimen has been found to be greater in a cold room than in a warm one, at least in fields up to 400 or 500. Probably this is to be explained by the influence of heat in diminishing the magnetic susceptibility of nickel, the retractions being really the same for the same intensity of magnetisation. Such small effect as appears to be produced by the action of the current may, therefore, be accounted for simply by the rise of temperature (2·6deg.) which it causes.

Tension has a large effect upon the magnetic retraction of nickel*; it is, therefore, the more remarkable that the action of a current, which operates so markedly upon iron, should in nickel be practically insensible.

Experiment 8.—The results with no current obtained for a strip of rolled cobalt, the length of which between the clamps was 10 cm., and the cross-section 1·82 square mm., are given in the first two columns of Table V.

TABLE V.—Cobalt Strip, section 1·82 sq. mm.

Magnetic field due to coil. C.G.S. units.	Retraction in ten-millionths of lengths. With no current through strip.	With 2 amperes through strip.	Difference.
[illegible]	1	1	0
50	2	2 5	−0·5
84	4	5	−1
100	6	6	0
119	7·5	8 5	−1
153	11	11·5	−0 5
209	[illegible]	16·5	−0·5
331	26	27·5	−1·5

Experiment 9.—A current of two amperes through the strip caused a heat elongation of about 600 ten-millionths, indicating, if the coefficient of expansion is taken as 0·0000125, a rise of temperature of 4·8deg. The retractions observed while this current was passing are set out in the third column of the table. From an inspection of the differences tabulated in the fourth column, it appears that the effect of the current is to increase the retraction very slightly.

According to Rowland the susceptibility of cobalt is increased by heating. The small additional retraction indicated when the current was passing was, therefore, no doubt due to the increased susceptibility consequent upon current heating. It may be noted that tension seems to have no material effect upon the magnetic retraction of cobalt.†

SUMMARY.

In an iron wire carrying a current, the maximum magnetic elongation is greater, and the retraction in strong fields is less, than when no current is passing. The effect of the current is opposite to that of tension.

The magnetic retractions of nickel and of cobalt are not sensibly affected by the passage of a current through the metals. (Tension considerably modifies the magnetic retraction of nickel, but not that of cobalt.)

ON THE CAUSE OF THE CHANGES OF ELECTROMOTIVE FORCE IN SECONDARY BATTERIES.‡

BY J. H. GLADSTONE, PH.D., F.R.S., MEMBER, AND WALTER HIBBERT, F.I.C., ASSOCIATE.

(*Concluded from page 502.*)

PART IV.—CONFIRMATIONS, THEORETICAL AND EXPERIMENTAL.

1. *Changes of E.M.F. with Two Similar Plates.*—In the discussion that followed one of our papers at the Physical Society, Mr. Hibbert mentioned that if two lead plates are put into acids of different strengths, separated by a porous diaphragm, a voltaic current is produced on completing the circuit. We have performed this experiment on two lead plates quantitatively, with reference to the E.M.F. produced, and have extended the observations to two peroxide plates. The method of experimenting was as follows: A divided cell was taken, in one compartment of which was placed sulphuric acid of about 0·2 per cent., in the other an acid varying from this strength upwards. A pair of lead plates was tested in the weakest acid, in order to ascertain that when immersed in the same liquid they gave no appreciable E.M.F. One of the lead plates was then put into a stronger acid, and the E.M.F. between it and the other determined by the condenser method. This was continued up to a 98 per cent. acid, but as the stronger acids act freely on spongy lead the observations beyond 22·5 per cent. were made with two solid lead wires. The results are given in the following table. The lead plate in the weaker acid behaved all through like PbO_2 plate to the other, and it is therefore called the + plate.

TABLE VI.

Acid round + lead plate. Per cent.	Acid round − lead plate. Per cent.	E.M.F. in volts.
0·2	0·65	0 036
,,	1·35	0·047
,,	2·85	[illegible]
,,	5·5	[illegible]
,,	10·5	0·082
,,	14·5	0·094
,,	18·0	0·102
,,	22·5	0·109
,,	36·5	0·150
,,	48·0	0·164
,,	57·5	0·204
,,	85·5	0·247
,,	98·0	0 266

A similar series of experiments was made with two peroxide plates. It is not likely, however, that the 99 per cent. acid had completely soaked into the meshes of the PbO_2. The peroxide in the weaker acid behaved like a lead plate, and is therefore called the − plate.

TABLE VII.

Acid round − PbO_2 plate. Per cent.	Acid round + PbO_2 plate. Per cent.	E.M.F. in volts.
0·2	0·65	0·054
,,	1·35	0·072
,,	2·85	0·095
,,	5 5	0·107
,,	10·5	0 134
,,	14·5	0·150
,,	18·0	0·158
,,	22 5	0 168
,,	36·5	0·215
,,	48·0	0·281
,,	57·5	0·359
,,	85·5	0·537
,,	99·0	0·643

The results are delineated in the diagram Fig. 7. If we consider Curve I. in Fig. 7—which shows the E.M.F. between two peroxide plates, one of which stands in sulphuric acid of only 0·2 per cent., and the other in strengths varying from that to 99 per cent.—we see at once that, while it rises through 0·589 volt, it is far from being a straight line. It rises very rapidly at first, then bends over and remains convex till about 18 per cent. is reached, when it becomes somewhat concave till about 57 per cent., after which it is tolerably straight. If we consider Curve II., Fig. 7—which shows the E.M.F. between two lead plates, one of which is in the weak and the other in stronger acids—we find that it follows a similar course, but the ordinates are only about two-thirds as large up to about 30 per cent., after which they are relatively much less. In Curve II., Fig. 2, we have an experiment in which the peroxide plate was placed in various strengths of acid, while the lead plate was retained in acid of uniform strength—namely, 14 per cent. The observations are only from 6·5 per cent. to 81 per cent., but on comparing it within those limits with Curve I., Fig. 7, it will be at once seen that the curves are identical in form. They are also identical in the absolute amount of the rise. The difference between 6·5 per cent. and 81 per cent. in Curve II., Fig. 2, is 0·404 volt, whilst in Curve I., Fig. 7, the difference is 0·401 volt. In Fig. 3 we have also observations on a cell with the PbO_2 plate in various strengths of acid from 43·5 to 85·5 per cent., while the Pb plate remains in acid of 27 per cent. On comparing this with the similar portion of the curve in Curve I., Fig. 7, we find that in both instances we are dealing with a line which is very nearly straight. The rise of E.M.F. in Fig. 3 between the points mentioned is 0·307 volt, and in Fig. 7 it is 0·308 volt. The close similarity both of the forms of the curves and the amount of the rise in each case, shows that the causes of the phenomena represented in Figs. 2 and 3 are the same as those in Fig. 7, within the range of the experiments. There is, however, this essential difference in the experiments—that while in Figs. 2 and 3 we are dealing with a peroxide plate and a lead plate, in Fig. 7 we are dealing with two peroxide plates, and the results can be dependent only on the varying strength of acid. This, of course, is a strong confirmation of the theory we have propounded.

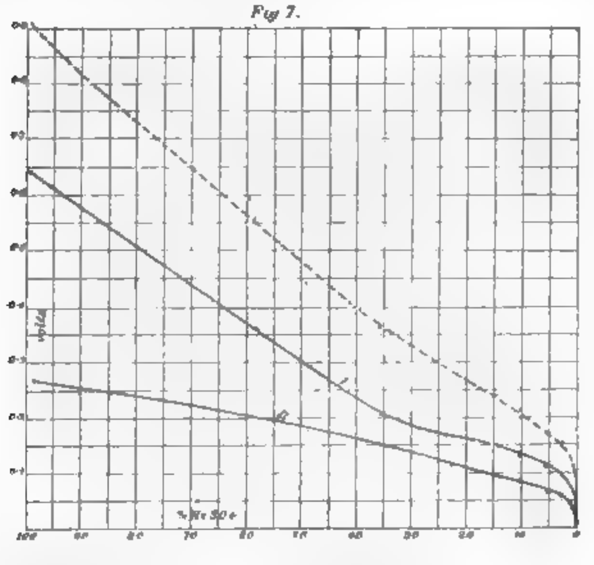
It is worthy of note that in the three experiments just compared together, the strength of the unchanged acid round the − plate was very far from being the same, varying, in fact, from 14 per cent. in Fig. 2, and 27 per cent. in Fig. 3, to 0·2 per cent. in Fig. 7. In other words, it does not matter what may be the starting point. This is just what might be expected if we are dealing merely with a differential result.

* Roy. Soc. *Proc.*, vol. xlvii., p. 469. † *Loc. cit.*

‡ Paper read before the Institution of Electrical Engineers.

If we compare Curve I., Fig. 7, with the lower part of Fig. 3, we observe a general resemblance, but with well-marked differences. In each case there is the rapid rise at commencement, with the subsequent bend over and convexity. But in Fig. 3 the concavity has nearly disappeared. There is also another difference. The rise in this case between 6·5 per cent. and 49 per cent. is 0·251 volt, instead of 0·183 volt in Fig. 7. These differences are easily explained. It will be remembered that the curve of Fig. 3 represents the variation of E.M.F. due to increasing strengths of sulphuric acid about the peroxide and the lead plate at the same time; while Curve I., Fig. 7, represents the increasing E.M.F. due to increased strength of sulphuric acid solely at the + PbO_2 plate. In Curve II. of Fig. 7 we have, however, the E.M.F. due to increasing percentages of sulphuric acid round a − Pb plate. Now it has already been stated that increasing the sulphuric acid round the two plates acts in opposite directions in the two cases, so that the potential difference between them in any particular acid will be the arithmetic sum of the separate effects. We have therefore added to the two curves of Fig. 7 together and obtained the dotted curve, Fig. 7. It will at once be seen that this combined curve closely resembles the experimental curve in Fig. 3, the concavity having almost disappeared. The rise from 6·5 to 49 per cent. has become 0·27 volt, only slightly exceeding that of the curve in Fig. 3 namely, 0·25 volt. We have thus resolved the rise and fall of E.M.F. during the charge and discharge of a cell into the two parts of which they are composed, and have determined them quantitatively.

Fig 7.



2. *Confirmatory Evidence from Changes in Resistance.*—The general correctness of the conclusions arrived at in Part III. is supported, not merely by the known changes in E.M.F., but also by changes in resistance as given by Prof. Ayrton and his colleagues. It is a matter of common knowledge that sulphuric acid varies very much in resistance according to its state of hydration; that the resistance is least for acid of about 30 per cent., though not changing very widely between 15 and 50 per cent.; and that if the acid became either weaker or stronger than these, its resistance rapidly increases. The following figures, calculated from Kohlrausch's results, will give an idea of the variation:

Resistance of sulphuric acid solutions.

$\%H_2SO_4$.	Relative resistance.
2·5	6·73
15·0	1·33
30·0	1·00
50·0	1·35
71·0	3·79
95·0	7·29

Hence we should expect that if the acid against the working surfaces of the plates is being concentrated during charge, or greatly weakened during discharge, there would be a marked increase in resistance. This is exactly what is found to be the case. In the *Journal*, vol. xix., p. 590, is a diagram showing the very rapid increase of resistance during charge, the increase beginning when the E.M.F. (about 2·17) indicates, according to our theory, a strength of sulphuric acid against the working surfaces of the plates of somewhere about 50 per cent.; also showing that at the end of the charge "the resistance is five times as great as its minimum value." This is particularly worthy of remark, because every other chemical change would tend to diminish, instead of increasing, resistance. The PbO_2 produced on the one plate, and the metallic lead produced on the other, are both much better conductors than the $PbSO_4$ which they replace. On page 592 of the same volume is another diagram, showing that when the discharge of this cell was begun the E.M.F. had fallen from 2·30 to 2·06 volts; and the resistance, which at the end of the charge was 0·0115 ohm, had fallen to 0·0038. We attribute both these falls to the same cause—namely, the reduction of the internal acid to about 30 per cent. Subsequently, the E.M.F. slowly diminished, while the resistance remained nearly the same for about five hours, when the E.M.F. more rapidly fell to 1·95 volts, and the resistance rose to 0·0055 ohm. This is more than would be expected from the above table of resistances, but it mus be remembered in this case that the other chemical changes—that is to say, the conversion of PbO_2 and Pb into PbSO—would also tend to increase, instead of diminishing, the resistance. We do not lay great stress on precise numerical relations in the case of resistance, as the change in the strength of the acid at the working surfaces is only one of the factors, though an important one.

3. *Confirmation from Mr. Crompton's Experiments.*—During the discussion on the papers by Prof. Ayrton and his colleagues, Mr. Crompton described two series of experiments which have a bearing on this subject.* In the first series some cells were discharged at rates varying from 11 to 66 amperes, and Mr. Crompton found that the ampere-hours delivered with a given range in P.D. fell from 300 to 125. He adds: "In every case the form of the curve is very definite, the turn-down as soon as the E.M.F. falls to 1·8 being very marked." This follows naturally, because at the higher rate of discharge the absorption of the acid in the pores has become much quicker, while the diffusion is scarcely affected, so that the weakening process goes on much faster The critical voltage of 1·8 simply indicates that the internal acid has become very weak. Mr. Crompton's curves and remarks show clearly that the fall is independent of the amount of PbO_2 remaining on the plate. In the second series of experiments thicker plates were used, and then he found a greater diminution of delivering capacity at the higher rates of discharge—in fact, it fell from 300 to 90 ampere-hours, and at the highest rate the fall began almost at once. This must be the natural result of the greater distance through which the entering acid has to diffuse.

4. *Confirmation from Thermo-Chemistry.*—It is possible to test the matter further by applying Lord Kelvin's law as to the relation between the E.M.F. of a cell and the thermal value of the chemical actions contributing to it. We hope to go into this matter more fully, and shall content ourselves at present with pointing out that the liquid in a secondary cell is a mixture, or a chemical compound, of two different liquids—sulphuric acid (H_2SO_4) and water, in varying proportions.

The simple problem is to determine what would be the voltage of a PbO_2 Pb cell in which there was nothing but pure H_2SO_4. From the thermo-chemical data which are before us we arrive at the value 2·627 volts. Our own determination, by means of the closest approximation which we could make to absolute H_2SO_4, is 2·607 volts. With pure water only in the cell, the calculated value is 1·35 volts, whilst in an experiment we found 1·36 volts. In determining the thermo-chemical values for mixtures of these liquids, it is necessary to subtract the heat of dilution from the available energy. On doing this, the calculated and experimental numbers do not agree so well as those already given, until we come to the most prominent part of the curve at about 6 per cent. acid. The theoretical value at this point, as determined from the known heats of combination and dilution, would give 1·901 volts, the experimental value being 1·89 volts. With lower figures than 6 per cent. it is evident that the change is not to be accounted for on thermo-chemical grounds, unless we admit a change in the chemistry as we approach pure water—a conclusion already drawn from other data. It is now easy to understand the large P.D. required for charging an accumulator. The current has to do extra work in concentrating H_2SO_4 at the PbO_2 plate, and the energy equivalent to that work must be obtained from an increased P.D. For a dyad gramme equivalent of H_2SO_4 concentrated from a 10 per cent. solution to 100 per cent. about 17,000 calories will be needed, and this = 0·37 volt. The calculated charging E.M.F. must therefore be at least 2·3 volts.

Part V. Consideration of other Suggested Causes of the Variation of E.M.F.

As other causes have been suggested for the changes in E.M.F., it is desirable to consider how far they are in accordance with the known facts of the case. It is evidently possible that the phenomena may be due to a number of causes co-operating.

1. It might be supposed that the reduction of the E.M.F. in discharge is determined by the relative amount of lead peroxide, which is destroyed or covered over with sulphate of lead. This is absolutely disproved by the experiments of Prof. Ayrton and his colleagues, which are graphically represented in Figs. 1 and 2, given on p. 661, vol. xix. of the *Journal* of Electrical Engineers. It will there be seen, from the determinations of the percentage of PbO_2 found on plugs removed, that the formation of the PbO_2 in charging, and the decomposition of it in discharging, is a fairly regular and continuous action. It gives no indication of the rapid changes at the commencement and termination of charging and discharging; while during the intermediate period, when there is little change of the E.M.F. for many hours, the rate of variation in composition is steady. This is indicated, as far as the discharge is concerned, by the dotted line in our Fig. 4, which is reproduced from the paper by Messrs. Ayrton, Lamb, Smith, and Woods. (See also remarks on Mr. Crompton's experiments, *ante.*)

2. Planté considered that the exceedingly high E.M.F. observed for the first few minutes on joining up a completely-formed cell, immediately after its removal from the charging circuit, was due to the gaseous hydrogen found on the Pb plate. Gladstone and Tribe,† while considering that this was possible, drew attention rather to the hydrogen occluded by the lead as a possible cause, but stated at the same time that this occluded hydrogen was exceedingly small in quantity. Frankland showed by a totally different process that it was practically *nil*. But hydrogen on one plate and oxygen on the other would not, under the conditions,

* *Journal*, Inst. Elec. Engineers, vol. xix., pp. 691, 692.

† "Chemistry of Secondary Batts.," p. 48.

account for as much as two volts, and this explanation is therefore inadequate.

3. Planté observed that a small quantity of lead peroxide is formed on the Pb plate during discharge; and Gladstone and Tribe found in this a reason for the state of electric equilibrium being approached before the peroxide on the PbO_2 plate is exhausted, and also for the fact that partly-discharged accumulators give an increased current after repose ("Chem. of Sec. Batts," pp. 27, 28). The last action is attributed to the extreme rapidity with which the lead peroxide formed on the Pb plate must be destroyed by local action. Mr. Robertson has recently added to this the observation that the formation of peroxide of lead on the Pb plate does not take place till the E.M.F. has fallen much below the normal value.*

We have already attributed the resuscitation of the E.M.F. on repose to the inflow of the stronger acid to the acting surfaces of the opposed plates, but we must look upon this formation of peroxide of lead, where it does occur, as contributing both to the reduction of E.M.F. and its resuscitation.

4. *Presence of some Form of "Active Oxygen."* It is well known that electrolysed sulphuric acid contains some hydrogen dioxide, which is probably due to the decomposition of persulphuric acid by water. Gladstone and Tribe showed that the presence of hydrogen dioxide in a cell must reduce the peroxide of lead: an observation confirmed by Robertson (*Proceedings*, Royal Society, vol. l., p. 107). Last June, both Mr. Robertson and Prof. Armstrong communicated papers to the Royal Society, in which they attach great weight to the presence of peroxides in the electrolyte, as causing a loss of efficiency. As only abstracts of these papers are published as yet, we cannot enter into any criticisms of their experiments. Mr. Robertson, however, in a lecture to the Society of Arts (*Journal*, Society of Arts, xl., p. 44), states that the "variations in E.M.F. appear to depend on which plate hydrogen dioxide is found at. When present at the peroxide plate it causes a rise, but when diffused through the acid and present at the lead plate, it causes a lowering of the E.M.F." We therefore made several experiments with the addition of hydrogen dioxide (both ordinary, and carefully purified from hydrochloric acid). Our arrangements admitted of adding the hydrogen dioxide to the electrolyte surrounding either the peroxide or the lead plate. Some of the determinations of E.M.F. were made by a condenser, and others by observing the current through an astatic galvanometer in series with a high resistance. We generally obtained a slight reduction (about 0·02 of a volt), but only what might be fairly attributed to the dilution of the sulphuric acid. It was still possible that some other form of "active oxygen" might accomplish what hydrogen dioxide had failed to do; and in order to determine whether these peroxidised products of electrolysis have really a different effect at the cathode and anode, we completed the charging of a pair of plates in a divided cell filled with 20 per cent. acid, and found that the "peroxides," or "active oxygen," existed only round the PbO_2 plate. We then reversed the plates in the compartments, so that the Pb plate stood in the liquid containing the peroxides (H_2O_2, persulphuric acid, etc.). One minute after stopping the charging current, and immediately before the reversal of the plates in the cell, the E.M.F. was 2·185 volts. After the reversal of the plates, the E.M.F. was measured by potentiometer at intervals, the results being given in the following table:

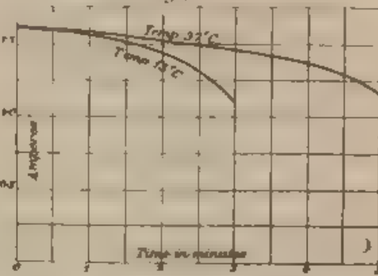
Time after reversal of plates. Minutes.	E.M.F. in volts.
1	2·163
6	2·081
8	2·078
10	2·066
12	2·063
15	2·055
22	2·044
45	2·031

There was evidently here no unusual fall in the E.M.F. The figures are embodied in the dotted curve of Fig. 1, and on comparing it with the fall for 18·5 per cent. acid they will be found so similar as to show that peroxidised compounds round the Pb plate had no visible effect. In each case the voltage evidently fell very slowly to a uniform value, and that value agrees very fairly with what we find for a 20 per cent. acid in Fig. 3. Through the kindness of Dr. H. Marshall, we were able to test the effect of adding some persulphate of potassium to the sulphuric acid in a cell about the PbO_2 plate, but without visible effect on the E.M.F. As far, therefore, as our own experiments are concerned, the E.M.F. appears to depend on the acid strength of the electrolyte, and not on the existence or the position of any peroxidised bodies dissolved in it.

ADDENDUM.

Although we did not undertake this investigation with the object of improving secondary batteries, there is one suggestion we should like to make—i.e., the desirability of promoting diffusion as much as possible. We believe that this is becoming more and more the practice among those who make accumulators, and the previous considerations furnish three reasons for such a procedure. It is well known that the accumulation of stronger acid at the lower part of a cell during its working is disadvantageous. This is believed to create differences of current density in different parts of the plate, and we have shown that it will also give rise to potential differences of fairly large value on each of the plates, and thus produce local action and the formation of lead sulphate. This inequality would be diminished if the diffusion of the acid could be promoted. The fall of E.M.F. at the close of discharge leaves a large fraction of the effective material not acted upon. This is mainly due to the weakness of the acid against the plates on account of the interstices being so much clogged; and it would be counteracted to a considerable extent if the diffusion could be increased. When a cell has been discharged at below 1·8 volts, there occurs the destructive action called "scaling." We are disposed to attribute this to abnormal chemical action arising from the very weak acid, and, if this be true, increased diffusion would in this case also act as a remedy. Such increased diffusion might be obtained either by agitation or by heating, and we thought it interesting to try the effect of higher temperature on the output of our small cell. The following curve, Fig. 8, exhibits the results of one experiment:

Fig. 8



The discharge curves at the higher temperatures generally showed an output some 40 to 50 per cent. greater than those at the lower. But it is evident that the higher temperature would increase local action and the chemical action of the acid upon the spongy lead. This might be met by a reduction in the strength of acid, but we have not tested at what temperature and with what strength the advantage is at a maximum. In addition to this suggestion, electricians will doubtless be able to make other useful applications of our conclusion that the changes of E.M.F. in a secondary battery depend on the strength of the acid that is against the working surfaces of the plates.

* Robertson's report to Prof. Ayrton, etc., *Journal* Institute Electrical Engineers, vol. xix., pp. 670-675.

METROPOLITAN ELECTRIC AND CABLE RAILWAYS.

The following is the report from the Joint Select Committee of the House of Lords and House of Commons on the electric and cable railways (metropolis), issued on the 23rd inst.:

1. The committee have met and have considered the matters referred to them, and have taken evidence submitted to them by the promoters of the various schemes, including that of electric and other engineers, as well as that of representatives of the London County Council, of the Corporation of the City of London, of the agent and surveyor of Lord Portman's St. Marylebone Estate, and of the Board of Trade.

2. The railway schemes that have been referred for their consideration are the following—viz., the Great Northern and City Railway, the Central London Railway, the City and South London Railway, the Waterloo and City Railway, the Baker street and Waterloo Railway, and the Hampstead, St. Pancras, and Charing Cross Railways.

3. The committee desire, in their report, to deal separately with the proposed Great Northern and City Railway.

4. The main objects of this scheme would appear to be to assist and relieve the great and growing local passenger traffic of the Great Northern line, and to afford it a new and direct access to the City.

5. It appears to the committee that there can be no reason why this scheme would not be considered by committees in ordinary course.

6. Further, the committees are convinced that direct communication through London for the main railway lines north and south of the Thames, whether for the convenience of their country or their suburban passenger traffic, would be of undeniable utility. And they cannot doubt that the growing needs of those lines will, sooner or later, lead to the construction of one or more of such communications.

7. But the purposes which the proposed new lines, with the exception of the Great Northern and City Railway, appear intended and adapted to meet are of a different character.

8. They are required to relieve the overgrown passenger traffic along the chief thoroughfares, to provide for the natural expansion of London, and to check the congestion of our metropolitan population by facilitating cheap communication outwards to a circumference which tends constantly to recede.

9. More such lines of communication are required with existing suburbs, and there is a growing need of their extension still further into the country in order to meet the increasing necessity for the removal of portions of the population to a greater distance.

10. The lines now in question will afford some portion of this much-needed accommodation; and where they terminate in or near the open country they are practically certain of further extension to meet the needs of a growing and spreading population.

11. It does not appear to the committee, with regard to any of these lines, that their construction would prevent that of other lines which the necessities of London may from time to time require, and they see no reason, therefore, for advising the postponement of the consideration, in ordinary course, of any of these Bills.

12. With regard to the question whether underground railways worked by electricity or cable traction are calculated to afford sufficient accommodation for the present and future probable traffic, the committee report that the evidence submitted to them was conclusively in favour of the sufficiency and the special adaptability of electricity as a motive power for the proposed underground tubular railways, whilst the method of cable traction appears also to be of recognised utility, especially in the case of steep gradient lines.

13. The proposed routes appear to be fairly satisfactory, considered as an instalment of the more complete accommodation necessary to meet the constantly increasing needs of London.

14. As to the terms and conditions under which the subsoil should be appropriated, the committee report that in the case of private property, not under the public streets, it appears to them to be desirable that the companies should be allowed to acquire a wayleave, instead of purchasing the freehold of the land, subject to the terms of the Lands Clauses Acts as to compensation.

15. In the case of public streets the committee think it expedient that the companies should be empowered to pass under the streets at sufficient depth without payment of compensation for the wayleave. In consideration of such free passage the committee advise that the companies should be put under obligation to furnish an adequate number of cheap and convenient trains.

16. The evidence submitted to the committee on the question of the diameter of the underground tubes containing the railways, has been distinctly in favour of a minimum diameter of 11ft. 6in.

17. The committee have directed the minutes of evidence taken before them, together with an appendix, to be reported.

THE FIRE AT SCOTT'S SUPPER ROOMS.

Last Friday at the inquest on the fire at Scott's Supper Rooms, Coventry street, Haymarket, **Mr. Edward Carstensen Segundo, A.M.I.C.E.**, of 28, Victoria-street, Westminster, said he was a consulting electrical engineer, and that, under the coroner's instructions, he visited the premises, 18 and 19, Coventry-street, W., on Monday last. In the house No. 18 there was not very much to be observed of the electric lighting, for the reason that the ravages of the fire had destroyed all traces of the manner in which the wiring had been carried out, but there seemed to him but little doubt that the fire originated in that house, on the ground floor. He had reason to think there was a possibility of the fire having originated at the top of the staircase leading down from the ground floor to the lavatory below. At that point the electric light mains passed for a distance of about 10ft. or 11ft. alongside the gas main. For about 3ft. the pipe would touch the casing which enveloped the main wires, and for the remainder of the distance the pipes would be about 2in. from the casing. Of course the pipe might have been bent during the fire and come into contact with the casing. It was absolutely impossible to say that the fire originated through a leak, but he held that it was quite possible for it to have originated through a leak going to earth from the mains through the gas-pipe, because the circuit supplying the electric light ran down there. It was a question whether that would be sufficient to cause a fire, but he had on more than one occasion himself seen a casing enveloping wires charred by a similar leak, also on an alternate-current circuit. He was therefore led to the belief that the possibility of its having caused this fire was not remote. From what he observed he thought it very possible that the fire originated near that place. He was influenced in his conclusion by the fact that the manager reported to him that on several occasions he had had to execute repairs to the wiring on account of the ravages of rats and mice. He did not think there was anything in the installation itself so seriously bad as to leave room for any charge of reprehensible neglect on the part of those whose duty it was to carry it out, but sufficient care, perhaps, had not always been taken to avoid metal pipes, a very important point in laying wires, especially on alternate circuits. Although the insulation was of a very fair character he thought it should have been done more heavily, particularly the mains which carried the wires near the gas-pipes. It was extremely unwise to systematically conceal wires behind panels, under floors, or in plaster. These mains were so concealed, and the gas-pipes plastered over. He understood that the building was insured in the Phenix office, but he was sure that their inspector would not have tolerated the position of the wires if he had known their proximity to the gas-pipes. Owing to the systematic way in which wires were concealed, there were no means of judging of the danger of the work. Supposing the fire to have originated through a leakage, the accident could have been avoided had the installation been subjected to an intelligent test from time to time. Had the wires in the first instance been designed so as to facilitate examinations and repair, any leak could have been discovered, localised, and remedied. His conclusion was that it was possible, and he would say probable, that the fire was caused by a leakage in the electric wiring, more especially if rats and mice had been gnawing at the casing. It seemed to be possible to put into a house an electric installation which might be of the greatest possible danger, and it was to be regretted that there were no set rules for the performance of the work. The danger of fire from an installation of the electric light appeared to be greater than in the case of an escape of gas, there being no smell. This was a matter which was well deserving of public attention, as the electric light was being so largely used.

The jury, after some deliberation, returned a verdict to the effect that the boys died from suffocation, and that the cause of the fire was unknown. They added that they considered the firemen and police to have done their utmost at the fire, and to be deserving of praise. *The Times.*

EXETER.

REPORT OF CITY SURVEYOR ON ELECTRIC LIGHTING.

City Surveyor's Office, Exeter, 8th May, 1892.

ELECTRIC LIGHTING.

Gentlemen,—As instructed by your resolution of the 13th ult., I have the honour to submit the following report on the lighting of the streets by the electric light—enumerating each section of it according to that on the agenda-paper of the Council meeting of the same date.

1. The area comprised in the second schedule of the provisional order for Exeter includes: That part of New North-road between Longbrook-street and the railway bridge, London Inn-square, Sidwell-street, High-street, Fore-street, New Bridge-street, Bedford-street, Bedford-circus, Queen-street, Gandy-street, Martin's-lane, South-street, North-street, and Paris-street. The number of gas lamps within this area, exclusive of those in courts or side streets, is 127, made up of nine large and 118 small lamps; this is the number strictly within the compulsory area, and does not include the lamps that would be displaced were the area lighted by the electric light. The total inclusive cost of the gas lighting of the area is as follows:

118 5ft. lamps at 73s.	£430	14	0
8 large lamps at 201s. 8d.	80	13	4
1 large lamp at 248s. 8d.	12	8	8
	£523	16	0

This sum does not allow of a comparison between cost of the two systems to be made, and for that purpose I went over the area and noted the number of gas lamps that could be dispensed with were the area lighted by electricity; the number that could be dispensed with is 182, including nine large lamps, the annual cost of which is—

173 at 73s.	£631	9	0
8 at 201s. 8d.	80	13	4
1 at 248s. 8d.	12	8	8
	£724	11	0

This sum is the annual cost of the lamps within and surrounding the compulsory area, which could be extinguished were the area installed with the electric light. It may be as well to explain here that the Council provide and fix the lampposts and the lanterns; the gas company lay on the gas, provide and keep in repair a governor and burner, light, extinguish, clean, keep in repair the lanterns, and paint the lampposts, their charges being:

Gas	£2	18	11
Lighting, cleaning, and extinguishing	0	11	3
Painting and repairs	0	2	4
Repairing governors	0	0	6
	£3	13	0

They are paid a further sum of 3s. 6d. for each new governor. I am of opinion that an annual charge for repairing governors is unnecessary.

2. To light the compulsory area according to the plan submitted herewith will require 56 arc lamps of 1,200 c.p. nominal each. The distance apart of these lamps is taken as the maximum at present for gas lamps—viz., 75 yards. There was an expression of opinion given at the meeting of the Council, which, I think, was generally agreed to, that if the whole area could not be lighted, the main streets and open places might. I have prepared a second plan showing the proposed positions of 32 arc lamps from St. Ann's to Exe Bridge and from High-street to the Obelisk, Queen-street.

3. The estimate of the first cost of lighting the area is based on the supposition that the energy is obtained from the Exeter Electric Lighting Company, and no item is included for conductors.

56 posts erected at £15	£840	0	0
56 lamps at £15	840	0	0
	£1,680	0	0

The estimate for installing 32 lamps, as shown on plan No. 2, would be as follows:

32 lampposts at £15	£480	0	0
32 lamps at £15	480	0	0
	£960	0	0

4. I have obtained tenders from the Exeter Electric Lighting Company, but find that at present they are not in a position to supply electricity to more than 32 arc lamps, or would prefer for the present to tender only for the smaller number of lamps. The two tenders from them are submitted herewith:

Tender No. 1.—For lighting by electricity certain streets within the Exeter Electric Light Company's, Limited, compulsory area: The Council to provide and maintain the necessary lamps and posts, with brackets and globes. The company to provide all necessary cables, machinery sufficient for supplying electricity to 32 arc lamps, distributed over the following places: Sidwell-street, Eastgate, London Inn square, High street, Bedford street, Bedford circus, Queen-street, Fore street, Gandy street, New Bridge-street. The lamps of the Thomson Houston type, and each of 1,200 nominal candle-power, and placed in positions approved by the city surveyor. The lamps to be burning an average of nine hours per night. A contract to be entered into for a period of seven years. Price, £22. 10s. per lamp per annum.

Tender No. 2. For lighting by electricity certain streets within the Exeter Electric Light Company's, Limited, compulsory area: The Council to provide and maintain the necessary posts and brackets; the company providing all necessary lamps, globes, cables, and machinery sufficient for supplying electricity to 32 arc lamps, distributed over the following places: Sidwell-street, Eastgate, London Inn square, High street, Bedford-street, Bedford circus, Queen-street, Fore street, Gandy-street, New Bridge street. The lamps of the Thomson-Houston type, and each of 1,200 nominal candle-power, and placed in positions approved by the city surveyor. The lamps to be burning an average of nine hours per night. A contract to be entered into for a period of seven years. Price, £24 per lamp per annum.

In No. 1 the price per lamp per annum is £22. 10s. In No. 2 the price is £24. At this rate the annual cost of installing the whole area would be—

Interest on outlay £1,680 at 4 per cent.	£66	4	0
Interest on outlay of lamps £840, 6 per cent.	50	8	0
56 lamps, at £22. 10s.	1,260	0	0
	£1,377	12	0

According to the second estimate the annual cost would be the same. The present cost of the lamps that would be displaced is, as already stated, £724. 11s., so that the cost of the electric lighting throughout the whole area, according to plan No. 1, is about double that of the present gas lighting, but there is no comparison between the efficiency of the two lights. To light the main streets and open places the annual cost would be—

Interest on outlay at 4 per cent.	£19	4	0
Interest for lamps, 6 per cent.	28	16	0
32 lamps at £22. 10s.	720	0	0
	£768	0	0

By tender No. 2 the amount will be £787. 4s. The number of gas lamps that would be displaced by this number of arc lamps is 127, the annual cost of which is £517. 7s. 4d. If you would be satisfied with the present posts, which are of the type ordinarily used, the cost might be reduced by £160, or £5 per post.

5. When the streets are to be opened up for laying the electric conductors underground, it would be advisable to lay down the cable for the arc street lighting at the same time. If the Council decide, in a few years' time, that the lighting of the main streets is not satisfactorily done by gas, and adopt the electric light, the extra cost of breaking up the streets to lay the necessary cables will be an item in the annual expense. I do not see much prospect of a reduction in the cost of electric lighting. It will vary in different localities according to the price of fuel, and also as to whether the first inception of the central stations provided for economical machinery, but I think before long communities will adopt it even at the increased cost over gas. The recent improvements in electrical machinery have been mostly in mechanical details. The dynamo has not had to go through the slow evolution or the trial and error that has brought the steam engine to its present pitch of proficiency; the principles involved were soon understood, and machines recently constructed are about as perfect as we may hope ever to find them. If the posts already erected in the streets are accepted, it would reduce the first cost considerably; and, as already stated, they are of the type usually adopted, with the exception of a slightly more ornamental cast iron basis—when stripped of the wires and cross-arms, and fitted with ornamental lamp brackets, they would not look so objectionable as they do at present. I find that the Exeter Electric Lighting Company are now waiting the decision of the Council to begin to lay their cables for private lighting underground.

That an increase in the illumination of the main thoroughfares is desirable is, I think, admitted; and, whether the streets are lighted by gas or electricity, there is evidently a demand for more light.—Your obedient servant, DONALD CAMERON.

COMPANIES' MEETINGS.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY, LIMITED.

An extraordinary general meeting of this Company was held on the 21st inst. at the City Terminus Hotel, Major Charles Jones in the chair, to consider the confirmation, as a special resolution, of the resolution that was passed on the 22nd ult. for increasing the capital of the Company to £400,000, by the creation of 100,000 new shares of £2 each, entitled to priority on a distribution of assets, and "entitled, out of the profits available for distribution in each year, to a preferential dividend of 10 per cent. and to a further dividend of 5 per cent. after a dividend of 15 per cent. has been paid on the existing shares."

The **Chairman** stated that very good reports had been received from France, where everything in connection with the Company's affairs was progressing well. Trial orders had been sent in from a large number of houses, including some of the best firms in France, and the orders were now being executed. He concluded by proposing the confirmation of the resolution.

Sir James Mackenzie seconded the motion.

In answer to questions, the **Chairman** stated that they had only been able gradually to bring the tanks into operation. M. Secrétan's report at the last meeting was correct—that there were 80 tanks, turning out about 100 tubes a day, at work. The output was perhaps now a little better than it was then; but the actual make of tubes for sale had not increased very materially, as they had been occupying some of the tanks, which would otherwise have been making tubes for sale, in coating mandrels with copper, and in making duplicate mandrels, so that they might be in a position to go on steadily with the work, and not have to stop the tanks while waiting for mandrels. They were turning out about nine to ten tons a week, and they would go on increasing this output. The factory was erected to produce, ultimately, 80 tons a week. M. Secrétan was pushing on as fast as he could, but he did not want to push on too fast, and make things badly. The secretary would be glad to give any shareholder information at the offices respecting the returns which were received periodically from France. The amount of preference capital they had allotted was between £24,000 and £25,000, and the Board were in addition making arrangements, under certain conditions, which they saw no difficulty in fulfilling, for placing another £40,000. The amount they had taken power to issue was to pay for the extra expenses of the factory, and to provide working capital to go on with. They had power to borrow money up to half the capital, and the Directors had exercised their authority in the interests of the shareholders. He could not state when they would be turning out 300 tons a month.

The resolution was then put to the meeting and confirmed.

NEW COMPANIES REGISTERED.

Cambridge Electric Supply Company, Limited.—Registered by E. Flux, Leadbitter, and Paterson, 144, Leadenhall-street, E.C., with a capital of £50,000 in £10 shares. Object: to acquire the powers, duties, and liabilities granted to and imposed upon the mayor, aldermen, and burgesses of the borough of Cambridge, by the Cambridge Electric Lighting Order, 1890, and to carry on business as electrical engineers and contractors for the supply of electricity for lighting, transmission of power, and other purposes, whether public or private, etc. The first subscribers are:

	Shares.
Sir B. C. Browne, Westacres, Newcastle-on-Tyne	1
J. B. Simpson, Hedgefield House, Blaydon-on-Tyne	1
Hon. C. A. Parsons, Heaton Works, Newcastle-on-Tyne	1
W. Bond, 3, Brookside, Cambridge	1
G. B. Finch, 1, St. Peter's-terrace, Cambridge	1
G. Whitmore, 4, Salisbury-villas, Cambridge	1
W. S. Melsome, Queen's College, Cambridge	1
W. R. Lamb, The Hall, Ryton-on-Tyne	1
H. C. Harvey, 57, Westgate-road, Newcastle-on-Tyne	1

There shall not be less than three nor more than seven directors. The first are the first six signatories to the memorandum of association. Qualification, £250. Remuneration to be determined by the Company in general meeting.

Electricity Supply Corporation, Limited.—This Company offers for subscription £100,000 in shares of £5 each, and £70,000 in 5 per cent. debentures, redeemable at par in 1900. The Company was incorporated on June 12, 1889, for the purpose of obtaining a provisional order for the supply of electric light and power within the parish of St. Martin-in-the-Fields. It is stated in the prospectus that the Company is already supplying 22,000 8-c.p. lamps. The existing plant is capable of supplying the requisite current for 40,000 lamps hung, and, with a small addition of boiler power, is equal to supplying 60,000 8-candle lamps hung. The proceeds of the present issue will be applied in discharge of the present debenture and other debts of the Company, which include moneys advanced by Messrs. Gatti and sums payable under agreements with them in respect of rights over their properties in the neighbourhood, and about £20,000 will be left for working capital.

R. C. Cutting, Douglass, and Co., Limited.—Registered by G. J. B. Porter, Wardrobe chambers, Doctors'-commons, with a capital of £20,000 in £5 shares. Object: to acquire the undertaking of lightning-conductor manufacturers and electrical engineers, now carried on by R. C. Cutting, Douglass, and Co., of Doctors'-common, and to carry on the said business in all its branches. Most of the regulations contained in Table A apply.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £2,803.

City and South London Railway.—The receipts for the week ending May 22 were £767, against £768 for the same period of

last year, or a decrease of £1. The total receipts to date from January 1, 1892, show an increase of £1,321, as compared with last year.

Islington and General Electric Supply.—As we surmised in our leader of last week, the prospectus for this Company is now issued. The share capital is £250,000 in 50,000 shares of £5 each, and of these 45,000 are now offered to the public. The Board is an exceptionally strong one, consisting of Sir F. A. Abel, E. W. Barnard, Major-General A. Ellis, Sir R. Pollock, and R. W. Wallace, with Prof. A. B. W. Kennedy and Mr. V. B. D. Cooper as engineers, and Mr. G. Kapp as consulting electrician. The secretary is Mr. R. McA. Inglis, and the offices 5, Victoria-street, S.W. The prospectus outlines the work and prospects of the Company, and tabulates information concerning half-a-dozen other companies. Messrs. J. E. H. Gordon and Co. have contracted for certain work at Islington, and in due course tenders will be required for Camberwell. The present issue provides money for two Islington stations, and leaves a good reserve for subsequent issue if required. Our views in regard to this Company were set forth somewhat fully last week, and with such fair prospects we do not doubt that the Company will meet with the success it desires.

PROVISIONAL PATENTS, 1892.

MAY 16.

9228. **Automatic electric masthead and side light indicator.** Edward Joseph Bonner Lowdon, 41, Reform-street, Dundee.

9253. **Improvement in apparatus for indicating electrically words, numbers, places, or other terms** Herbert Hampton Hall, 5, Marlborough-road, Liscard, Cheshire.

9282. **Improvement in multiple commutator apparatus for telephonic installations with metallic circuits of the system Berthon.** Charles Denton Abel, 28, Southampton-buildings, Chancery-lane, London. [Société Générale des Téléphones (Reseaux Telephoniques et Constructions Electriques), France.] (Complete specification.)

MAY 17.

9300. **Electrically-heated matrix press.** Willis Mitchell, 36, Chancery-lane, London. (Complete specification.)

9319. **Improvements in or connected with anodes for the electrolytic decomposition or formation of chemical compounds.** Alfred Henneton, Temple-chambers, London. (Complete specification.)

9331. **Improvements in the mode of and apparatus for the transmission of currents through conduits for the propulsion electrically of railway cars, etc.** John Walter Grantland, 323, High Holborn, London. (Complete specification.)

9343. **Improvements in electric connectors for current converters.** George Dexter Burton, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

9346. **Apparatus for the production by electrolysis of chlorine and alkalies.** Carl Kellner, 46, Lincoln's-inn-fields, London.

9347. **Process for the separation of the alkali obtained by electrolytical decomposition of halogen compounds from the electrolyte which has not been decomposed.** Carl Kellner, 46, Lincoln's-inn-fields, London.

9356. **Improvements in apparatus for distributing electric currents for heating purposes.** George Dexter Burton, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

9362. **Improvements in and relating to electric metal-working apparatus.** George Dexter Burton, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

9365. **Improvements in and relating to electric motors.** Robert Lundell and Edward Hibberd Johnson, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

9379. **Improvements relating to the heating and working of metal bars by electricity.** George Dexter Burton, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

9380. **Improvements in mechanism for converting electric currents, and in the method of applying the same to the working of metals.** George Dexter Burton, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

MAY 18.

9409. **Improvements in electromagnets for organs and for other suitable purposes.** James Jepson Binns, 8, Quality-court, Chancery-lane, London. (Complete specification.)

9425. **Improvements in electrical switches.** Alexander William Stewart, 115, St. Vincent-street, Glasgow.

9450. **Improvements applicable to electric bells and other instruments.** Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London. (Richard Varley, United States.)

9435. **Electric gong.** Henry Nehmer, 4, Grafton-street, Gower-street, London.

9470. **Improvements in electric pushes.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Carl Jörns, Germany.) (Complete specification.)

MAY 19.

9486. **Improvements in switches and crossings for the trolley wires in the overhead system of electric traction.** Alfred Dickinson, The Tramways Depôt, Darlaston.

9496. **Improvements in telephones.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London.

9500. **Improvements in electric switches.** John Macintosh Mackay Munro and James McFarlane, 154, St. Vincent-street, Glasgow.

9515. **Improvements in ammeters and voltmeters.** John Perry and Charles Edward Holland, 4, Redington-road, Hampstead, London.

9536. **Improvements in systems of electric distribution.** Herbert John Allison, 52, Chancery-lane, London. (Cyprien Odillon Mailloux, United States.)

9541. **An improved electric accumulator or secondary battery.** Friedrich Schmalhaus, 433, Strand, London. (Complete specification.)

9559. **A new or improved electrical sounding apparatus.** Arthur John Thomas, 76, Chancery-lane, London.

9566. **Improvements in electric percussive tools.** Llewelyn Birchall Atkinson, 1, Queen Victoria-street, London.

9569. **Improvements in or connected with electric batteries.** Charles Percy Shrewsbury and John Laskey Dobell, 57, Chancery-lane, London.

MAY 20.

3113A. **Improved means for conveying currents of high tension and in appliances used for this purpose.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, Chancery-lane, London. (Date claimed under Patents Rule 19, 17th February, 1892.)

9612. **Improvements in dynamo-electric machines.** William Lowrie, 433, Strand, London.

9613. **Improvements in or relating to the method of maintaining or regulating the potential in electric current circuits.** William Lowrie, 433, Strand, London.

9623. **Improvements in electric batteries.** Jean Vernhet, 323, High Holborn, London.

MAY 21.

9678. **Improvements in electricity distribution.** William Burgess Edgar and John Macintosh Mackay Munro, 154, St. Vincent-street, Glasgow.

SPECIFICATIONS PUBLISHED.

1891.

8009. **Electric call apparatus.** Poore.

8874. **Telephones and electric bells.** Bennett and Hides.

9048. **Illuminating road vehicles electrically.** Cogan and others.

9887. **Microphonic or telephonic transmitters.** Collier.

10832. **Electrical transformers.** Woodhouse and Rawson United, Limited. (Preschlin.)

10877. **Hauling electric, etc., cables.** Voysey.

11004. **Electric accumulators.** Rousseau.

11016. **Dynamo-electric machines, etc.** Callendar.

11048. **Electrical mains.** Johnson and Phillips.

11060. **Thermo-electric batteries.** Giraud.

11157. **Telephone transmitters.** Radcliffe and Spagnoletti.

22657. **Electrical signalling.** Watts.

1892.

4244. **Ships' telegraphs.** Endall.

6050. **Electric conductors.** Thompson. (Williams.)

6083. **Incandescent electric lamps.** Smith.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{1}{4}$
— Pref.	—	$2\frac{1}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	$20\frac{1}{2}$
House-to-House	5	$5\frac{5}{8}$
Metropolitan Electric Supply	—	$7\frac{5}{8}$
London Electric Supply	5	$\frac{7}{8}$
Swan United	$3\frac{1}{2}$	$4\frac{1}{8}$
St. James'	—	8
National Telephone	5	$4\frac{3}{8}$
Electric Construction	10	$6\frac{1}{4}$
Westminster Electric	—	$6\frac{3}{16}$
Liverpool Electric Supply	5	$5\frac{1}{8}$
	3	$3\frac{1}{8}$

NOTES.

The New Telephone Company have now over 2,800 supporters on their lists.

Ancient and Modern is the title given to the City lighting—gas and electric.

Appointment.—A second assistant to the lecturers at the Royal Artillery College is to be appointed—22nd inst.

Bristol.—Tenders for condensers, pumps, and pipes at Bristol are invited, as will be seen by the advertisement.

Weybridge.—The Board of Trade have been asked to extend the time for lighting Weybridge for another three months.

Hanley.—The tenders for the central station plant for Hanley are to be sent in to Mr. Arthur Challinor, town clerk, by the 20th inst.

Chiswick.—No decision has yet been come to by the Chiswick Local Board with reference to the transfer of their electric lighting powers.

Dundee.—The Dundee Gas Commissioners opened the tenders for electric station plant on Wednesday. Most of the large firms have tendered.

Fulham.—The Board of Trade has informed the solicitor to the Fulham Vestry that the West London electric lighting order will not be proceeded with.

Oxford.—The formal opening of the Oxford central station is to take place on Saturday, June 18, when the current will be switched on by the Mayor.

Bacup.—A large meeting of the Bacup ratepayers have passed a resolution unanimously that the steps for the introduction of electric lighting should be accelerated.

The Late P. Willans.—In our obituary note last week, Wednesday was inadvertently mentioned as the day of the accident to Mr. Willans, when it should have been Monday.

Brussels.—We learn from an authoritative source that no absolute decision has yet been formally made with reference to the proposed central electric station for Brussels.

Worcester.—The Worcester and the Midland Tramway Companies are arranging an amalgamation. The occasion might not be unfavourable for consideration of the question of electric traction.

Huddersfield.—The tender of the Bradford branch of Messrs. Woodhouse and Rawson United, Limited, for wiring and fitting the borough surveyor's office at Huddersfield has been accepted.

Niagara.—The option of utilising the Niagara Falls for electric transmission granted to Ferranti has been made over to a company, who will probably execute the scheme suggested with Ferranti apparatus.

Ferranti Meters.—The Ferranti meter has been provisionally sanctioned by the Board of Trade, and Messrs. Ferranti have already received over £3,000 worth of orders for these meters from supply companies.

Indo-China.—The municipality of Haiphong, French Indo-China, has decided upon using electricity for street lighting. A scheme to light the town of Surabaya, in Netherlands India, by electricity is also on foot.

'Bus Lighting.—A Press view of the lithanode batteries and electric lamps referred to in our leader was held last night at the Lithanode Works, 64, Millbank-street, when the lamps shown in operation attracted much interest.

Bishop's Stortford.—Tenders are required for the lighting of the public streets of this town for one year from August 16th. Tenders are to be sent, on forms supplied, to Mr. W. Gee, North-street, Bishop's Stortford, by the 18th inst.

Azores Cable.—We see it stated that the Telegraph Construction and Maintenance Company intend to claim heavy damages from the Portuguese Government for overriding the provisional contract long ago signed for the Azores cable concession.

Barnet.—The arbitrators in the Barnet case have stated that the award will be made in general terms, and not on specific items. It was also to be considered that any sum that the Barnet Local Board might have to pay would not include the purchase of the plant, which would remain the property of Mr. Joel. The award will be made on July 1.

St. Saviour's Board District.—The St. Saviour's Board has received a statutory notice from the City of London Electric Lighting Company intimating that they intend to apply to the London County Council for permission to erect a wharf on Bankside. The Board have however, decided to strenuously oppose the application.

Telegraph Stores.—The North-Eastern Railway Company are asking for tenders during the six months ending December 31, 1892, delivered in York, for (1) telegraph apparatus, and (2) telegraph wire and line stores. Forms of tender are to be obtained from Mr. Graves, Telegraph Department, York, and tenders must be sent in by 7th inst.

Accident.—A fatal accident is reported to a child at Birmingham, who was run over by one of the electric cars. Of course there is no reason to suppose that the accident was due to the fact that the car was driven by electricity, but there ought to be means absolutely enforced in all cars to make it virtually impossible for a car to run over a human being.

Hoist by His own Petard.—The electricians' department at University College, Bristol, was demolished on Wednesday by a huge mass of stone dislodged by a stroke of lightning which struck the college. The resident engineer, Mr. Partington, of the Salford sewage works (where, curiously, electricity is being also used), was, we are sorry to hear, unfortunately struck during the same storm and instantly killed.

Automatic Transformers. — Messrs. Ferranti's automatic cut in and out transformer for regulating supply according to demand, and so avoiding loss by hysteresis, is now completed, and will be tested practically after Whitsuntide. It is likely to prove a most important improvement for alternate-current stations, and as Messrs. Ferranti hold the master patent, the invention is likely to prove remunerative.

Gramme Winding.—"The objection to Gramme winding for multipolar machines," says *Industries*, in answer to an enquiry by a correspondent, "is that if the armature be the least out of the centre, or if some of the fields be of a better quality of iron than others, the armature is not evenly loaded; at light loads it is partially short-circuited on itself, and at full load the current density is greater on one side than on the other."

Whitehaven.—Meetings of the Harbour and Streets Committee of the Whitehaven Board of Trustees have been held during last week, and it is understood that it was decided almost unanimously to endeavour to obtain the adoption of the electric light for the harbour and the public lamps of the town. A deputation of the trustees will visit one of the Lancashire towns, with the object of inspecting the practical working of the electric light.

Bradford : Hotel Lighting.—The Great Northern Railway Company have recently purchased the Victoria Hotel, Bradford, and have entrusted the complete decoration and refurnishing of same to the well-known firm of Marsh, Jones, and Cribb, of Leeds, the sub-contract for the bell-work and electric light being in the hands of the Bradford branch of Messrs. Woodhouse and Rawson United, Limited. The current required is to be obtained from the Bradford Corporation's central station.

Aberdeen. — The Education Committee of Robert Gordon's College, Aberdeen, have resolved to ask a remit from the governors to further consider the suggestion they made as to the necessity of providing a new and more powerful dynamo in room of the one at present in use, and to consider and report upon the whole question of the electric lighting of the college, with special reference to the proposals at present under the consideration of the Town Council for lighting the city by electricity.

Hull.—Tenders are required by the Hull Corporation for the supply of an overhead travelling crane for the electric light station. Specifications and forms of tender may be obtained from Mr. F. Harman Lewis, borough electrical engineer, Central Police Station, Hull, on payment of one guinea, to be returned on receipt of tender. Cheques must be payable to Borough Treasurer, Hull. The tenders are to be sent to the chairman of the Electric Light Committee, Town Clerk's Offices, Hull, by noon on June 10th.

Telegraph Apparatus.—Tenders are required by the Caledonian Railway Company for telegraph and electric appliances for the 12 months from 1st August next. Specifications and forms of tender may be obtained from Mr. James Lorimer, superintendent of stores, Caledonian Railway, Charles-street, St. Rollox, Glasgow. Patterns may be inspected on and after Monday, 6th June, at the company's stores, Charles-street, St. Rollox. Tenders to be sent in to the Secretary, 302, Buchanan-street, Glasgow, not later than Monday, 20th June, 1892.

Glasgow.—A lively discussion has been going on in the *Glasgow Herald* with reference to electric cars. Mr. Moses Buchanan has put forward his feelings that the overhead wire system for electric cars is dangerous and unsightly. Other correspondents have pointed out the efficient application of this system in Leeds and in America, more particularly in Boston, where, according to the Boston papers, there are now between 300 and 400 cars on the lines, and the traffic has increased so greatly that plans are being got out to open up larger new thoroughfares.

Training Ship.—Messrs. Paterson and Cooper have been selected by the London School Board for the contract of providing a system of electric lighting for the training ship "Shaftesbury." We believe the amount involved in the estimate is £1,068, while Messrs. Fraser and Sons are to supply the necessary boilers and furnaces at a cost of £423, the Board having voted a sum not exceeding £1,500 for these purposes. Mr. Howard Swan was employed by the Board to draw up the needful specifications, and will supervise the carrying out of the work.

Engineering Exchange. — The new Engineering Exchange seems to have got into good and active company, and the inauguration of this exchange, together with the removal of the Jerusalem Shipping Exchange (established 1625) to new offices in 22, Billiter-street, was celebrated on Tuesday by a dinner. Sir Albert Rollit, M.P., presided, and speeches were made emphasising the importance of our shipping trade, and the union of the engineering profession thereto, by the chairman, and Mr. G. Candy, Q.C., Mr. H. Kimber, M.P., Mr. W. W. Beaumont, Mr. Reginald Bolton, Mr. F. Rawson, Mr. Flaxman Haydon, and others. A smoking concert followed the dinner and speeches.

Manchester.—As will be seen from their advertisement, the Gas Committee of the Manchester Corporation are prepared to receive applications for the position of clerk of works, to superintend the construction and erection of the dynamos, engines, boilers, and other apparatus, and the laying of the mains and conductors in connection with the electric installation. The salary will be four guineas a week, and the appointment may be made permanent at a salary to be agreed upon afterwards. Applications must be forwarded to Mr. C. Nickson, superintendent, Gas Department, Town Hall, Manchester, by the 24th inst., addressed to the Chairman of the Gas Committee, Manchester.

Eastbourne.—The Eastbourne Electric Lighting Company, owing to the growing success of their enterprise, have decided to reduce their price from 10d. to 9d. per unit. The company seems to be in a good condition, and a satisfactory report is promised. A considerable profit was realised last year, the debenture interest has been paid, and, after a fair sum put aside for depreciation, a small profit still remains, and the reduction of price may be expected to still further popularise the light. The efforts of the enterprising chairman, Mr. George Boneton, seconded by the able manager and electrical engineer, Mr. Wilkinson, have secured a sound result to the company, which we hope will continue a prosperous career.

Derby.—The Electric Lighting Committee of the Derby Town Council have, in conjunction with Sir Frederick Bramwell and Mr. Harris, considered various sites for the buildings and works in connection with the installation of the electric light for the borough, and have decided to recommend the use of the land in Silk Mill-lane for the buildings, the unoccupied part of the adjoining island in the Derwent to be used for storage and other purposes in connection with the work. The site on the island was until recently occupied by the old silk mill, the first ever built in England, which was erected by John Lombe early in the eighteenth century, and which had to be pulled down in consequence of its dangerous condition.

Wetley Abbey, Stoke-on-Trent.—The Manchester branch of the Brush Electrical Engineering Company have just completed an installation at the residence of J. Hartland, Esq., which is noteworthy in that it demonstrates the success with which electric lighting can be carried out in a country mansion with a petroleum engine as the prime motor. The installation consists of 60 16-c.p. lamps, with a battery of accumulators; a Priestman oil engine of 7 brake h.p. is used to drive a Victoria dynamo, which supplies current to the cells. The switchboard is arranged so that the lamps can be fed either direct from the storage battery, from the dynamo and battery in conjunction, or from the dynamo direct. The work of the whole plant is very satisfactory.

Waterford.—Mr. J. J. O'Sullivan is the champion of the electric lighting project in Waterford, and has written some trenchant letters in the local paper. If the Council forego their provisional order now and bind themselves to the gas company for another five years, he points out they will not be able to oppose a local electric company in another two years, and will lose the supply. Mr. W J. Smith had maintained as a "stern fact" that an installation would cost £3,000 to £4,000 a year to run, and Mr. Sullivan replied that surely Mr. Smith has overlooked the fact that the Corporation may expect a revenue as well as expenditure. Meantime the question is still being debated. The best thing the Council could do would be to invest on the advice of a competent expert.

Southampton Baths.—The Baths and Washhouses Committee of the Southampton Town Council reported at the last meeting the receipt of 36 tenders for the electric lighting of the public baths, and unanimously recommended the Corporation to accept the tender of the Newton Electrical Engineering Works, of Taunton, for carrying out the work for £324, subject to the sureties being satisfactory, also to the dynamo and fittings being satisfactory to Mr. Aldridge, their consulting engineer, all subject to the approval of the Local Government Board. Mr. Le Feuvre enquired how it was that Mr. Aldridge was introduced into the matter, and what remuneration he was to get? The Mayor said it was usual to call in an expert, and his remuneration would be £20. The report was adopted.

Central London Station.—The great want of London for years has been a central City railway station joining the main lines, and this want the electric railway seems destined to fulfil. The engineer to the Commissioners of Sewers has brought in a report, wherein he gives details of a large station, with subways for the public, to be formed beneath the street on an area bounded by the Poultry, Victoria-street, the Mansion House, Cornhill, and Threadneedle-street. Public subways will be provided at a short distance below the surface, having eight staircases leading down. From these, lift-shafts will go to the station level, 80ft. below the surface. The company will have the finest site in the world practically free, though the cost of construction will be nearly £40,000. It has been determined that all persons within a certain area shall be deemed affected, and entitled to some compensation.

Tramcar Lighting.—What managers of tramcars feel to be needed for the lighting is some neat portable battery with electric lamp, which can be economically run, easily slipped into place, and which will light the car "from the roof." The first desiderata are the same as for 'bus lighting, to which attention is elsewhere called. For the latter, lighting from the roof, which is really an important point, all that is necessary, of course, is a flat battery with the lamp beneath, with reflector and some hooks or sliding catches. This is perfectly simple; still, someone must do it and show the lamps. We commend the idea to both tram managers and lamp makers. It is, indeed, quite possible that this will eventually prove the easiest and cheapest method of lighting railway trains, instead of the separate plant now used for train lighting, for at base the problems are similar, and no train in England requires more than eight hours' charge.

Train-Lighting Plant. — Mr. J. Evelyn Liardet, writing to us from Palace-chambers, 9, Bridge-street, Westminster, states in effect that he, not Stroudley and Houghton, was the true inventor of the railway train-lighting plant, an improved form of which, as manufactured by the Brush Company, was illustrated and described by us last week. He mentions his patent (5,418, 10th December, 1881) as being prior to that of Stroudley and Houghton (2,579, of 23rd May, 1883) and almost the same, and protests against the credit being given to them as the inventors. So far as the dates of the first electric train-lighting plant are concerned, these can be seen on reference to the Patent Office library, but the columns of a technical journal are not the proper place for insistance and proof of the priority or identity of inventions, which can usually only be settled in the Law Courts. We see no reason, however, not to mention Mr. Liardet's claim for the priority.

Tesla's Experiments.—"Some of Mr. Tesla's most striking experiments," remarks Mr. Arthur G. Webster in discussing Ohm's law in the *Electrical World*, "depend on the illumination of tubes or lamps without electrodes, or with but one. An experiment was performed several years ago by a gentleman in Vienna (I think Dr. Moser) with a double Geissler tube without electrodes. One tube surrounded the other, which was exhausted. On bringing the tube near an induction coil, and beginning to exhaust the outer tube, the latter glowed while the inner remained dark, being screened from action by the conducting gas in the outer tube. On highly exhausting the outer tube its conductivity diminished, and the inner tube began to glow, while finally the outer ceased. To my mind this experiment is as instructive as any of Tesla's. There is nothing, of course, in this to detract from the great interest and beauty of Tesla's experiments, but I am inclined to agree with Mr. Wimshurst that the principal difference between these and others is in the expenditure of energy involved."

Derby.—The recent decision of the Derby Town Council to undertake the supply of electricity has naturally aroused great interest among the inhabitants of the town. In order to foster this interest to the utmost, the enterprising Derby firm, Messrs. John Davis and Son, of All Saints' Works, have had on view at their establishment a collection of domestic electrical arrangements, for demonstration of the usefulness of "electricity in the house." Besides electric light in lamps of various kinds, and electric motors applied to engineering work, Messrs. Davis have a set of electric cooking apparatus. The electric kettle boiled water in a few minutes from the time of turning on the switch; an invalid or business man in a hurry can make their own breakfasts or teas without trouble. An electric saucepan shows how an egg can be boiled, or stew prepared, with as little difficulty, and with the electric grill chops, steaks, and pancakes are turned out with despatch. The electric heaters and bath warmers are much admired for efficiency and cleanliness. These sets of apparatus, already known to visitors at the Palace, create much interest in the provinces, and much business should be done in this direction. The electric Blackman fan is also greatly appreciated.

Breslau Central Station.—Some interesting particulars are given by C. Dihlmann in *Elektrotechnische Zeitschrift*, of the Breslau central station, abstracted in the *Journal* of the Institution, as follows: "The station is worked on the three-wire system, with Tudor batteries capable of running 2,500 lamps (16 c.p.) for 3½ hours, the total capacity of the station being 8,000 lamps. There are three horizontal compound condensing engines, 250 h.p. each at 150 revolutions, built by the Gorlitzer Company, each driving two Siemens and Halske dynamos, direct coupled, on each side. The latter work up to a maximum of 175 volts and 465 amperes for charging, and 130 volts and 625 amperes when working direct on to the mains. There is no separate commutator, the current being taken off by brushes at six points on the armature itself. Armoured lead-covered cables are exclusively used, and principally laid under the foot pavement. Automatic gear is provided on the feeders to maintain constant E.M.F. at their ends by switching them on to different cells. The station was started in August with 3,000 to 4,000 lamps joined up which number had risen to 10,000 before Christmas 40,000 metres of cables are already laid, and 30,000 metres more will be down shortly."

Taunton.—The report by Mr. Kapp to the Taunton Town Council upon the central electric station appraised the machinery and plant, which he thought well for them to purchase, at £5,250, leaving the rest of the plant to be disposed of by the company themselves. As this arrangement did not meet the views of the company, a subsequent

report suggested that the whole should be bought for £9,300, and that the Council take upon themselves to sell the plant not required in the reorganisation of the station. The joint committee have passed a resolution empowering a sub-committee to purchase and make terms for carrying on the works until a provisional order could be obtained. At a preliminary meeting of the shareholders of the electric lighting company, it was agreed to recommend the acceptance of the offer of the Town Council to purchase for £9,300, and a meeting of the shareholders has been called for June 2 to consider this offer. Alderman Standfast, however, writes to the papers that no offer can have been really made, as no vote of the Council has yet been taken. He suggests also that if the Council must buy, the company ought first to liquidate and get rid of their liabilities. As the subject is important to the ratepayers, he demands an actual division should be taken.

Proposed Electric Tramways for Hull.—A special meeting of the Hull Town Council was held on Monday to consider an agreement which the Works Committee proposed should be entered into with a syndicate for the establishment of electric tramcars in the borough. The mayor, Mr. E. Robson, was in the chair. Alderman Larard, chairman of the Works Committee, moved the adoption of the minutes, and stated that the present tramways being in liquidation it was proposed, by virtue of the powers they possessed under the Act, to purchase the system, also the system of the Marfleet Steam Tramways Company, and amalgamate the whole. The agreement provided that the Corporation should relay the system, putting down double lines along the principal thoroughfares, and let the whole to the syndicate, who should provide rolling-stock and plant for working the line by electricity, and pay the Corporation a percentage to cover interest on outlay and maintenance of the lines and generating stations, and also make a deposit of £14,000. It was further arranged that the whole system should become the property of the Corporation in 30 years. Alderman Wilde seconded the resolution. A long discussion followed. The principal ground of objection urged was that the Corporation would have no substantial security in case the new company failed to fulfil its obligations. On the motion of Mr. Massey, seconded by Mr. Smith, the minutes were referred back for reconsideration.

East-end Electric Railway.—A proposal for the relief of the congested population in the East-end by the construction of an electric railway, to be paid for on the betterment principle, has been put on the County Council programme by Mr. Saunders for discussion at an early date. Not long ago the chairman of the Great Eastern Railway stated that a fare of 2d. for a journey from Enfield to Liverpool-street and back remunerated his company if there were 500 passengers in the train. This being so, Mr. Saunders concludes that on the electric railway line, the interest on the cost of which would be paid by the improved value of the land, a penny fare for 20 miles would pay, seeing that electric trains are smaller and cheaper than the trains run by the Great Eastern Company. Mr. Saunders will therefore propose "that the Council instruct an experienced railway engineer to advise it as to the best route for an electric railway passing underground through Whitechapel, rising to the surface at suitable points, and extending about 20 miles north and south from the centre of the railway at Whitechapel; this advice to be obtained with a view to preparing plans and estimates, and submitting to Parliament a scheme for the construction of such a line. The cost to be paid by the application of the betterment principle to the increased value of land imparted by the railway. Workmen's trains to be provided at a net charge not exceeding 6d. per week for travelling 10 miles daily and return."

Technical Education.—The Special Committee on Technical Education reported on Tuesday to the London County Council that they regarded it as indispensable, in order that they might be in a position to make any useful recommendation to the Council, that they should first ascertain what provision was already being made for technical education in London, to what extent the ground was being covered by other agencies, and in what way, and by what body, any deficiencies could be best supplied. This information, they stated, did not at present exist in any form in which it could be laid before the Council, and they had come to the conclusion that it was necessary temporarily to engage the services of a gentleman who should prepare a detailed statement, make any necessary enquiries under their direction, and act at the same time as secretary. They had selected for this task Mr. Hubert Llewellyn Smith, M.A., B.Sc., who would devote himself to the work during the four months ending September 30th next, and to whom they had agreed to pay an honorarium of £250, which would also cover any minor personal expenses incidental to his enquiry. The cost would be met from the sum of £500 which was placed by the Council at their disposal for the general expenses of enquiries under their reference. The course taken was approved.

Huddersfield. — The following is the description, apparently official, of the system of electric lighting which is to be introduced into Huddersfield: The system is a high-pressure alternating-current supply to converting stations, from which a low-pressure supply at constant pressure is given to consumers. The converting stations will, as a rule, be chambers below the level of the streets. In special cases of large installations the converting stations will be special fireproof erections in the basement or other convenient parts of the building. The chambers below level of the street will be constructed and fitted as follows: The chamber will be of ample size and suitable construction. The entrance to the chamber will be no larger than may be required to allow of the entrance of a man or the withdrawal of a transformer, and will be closed externally in the same manner as other street boxes. The covers will be fixed in stout cast-iron frames, to which will be attached in electric continuity therewith strips of metal laid immediately underneath the adjacent pavement. Below the external cover there will be fixed a second metal cover, independently supported, free from metallic connection with the external cover, and effectually connected to the earth by means of an efficient electrical attachment to the underground iron pipes or metal conduits. Adequate means will be adopted to thoroughly ventilate these chambers, and to prevent any accumulation of gas or water. The power given to any single converting station will in no case exceed a maximum of 100 h.p. without the written consent of the Board of Trade, and every transformer will be protected by a suitable automatic quick-acting cut-off, which will act should the proper maximum current be exceeded by the amount of 40 per cent. The high-pressure mains will be concentric, insulated with vulcanised rubber drawn into paper tubes, bedded in bitumen, and protected by a cast-iron casing. The low-pressure mains will be single cable, drawn into paper tubes, and protected in the same manner.

Three-Phase Currents at Heilbronn.—Will the three-phase current as shown at Frankfort become really practical as one of the methods for electric central station work? This is a question that a good many electrical engineers have posed themselves since their visit to Germany last year. The idea has not yet been seriously entertained in England to utilise the "rotary current" for

any central station, though it was tentatively discussed for one of our university towns, and has been also considered, we are informed, for one of the towns in Ireland at present intending to adopt electric lighting. But these projects are without definite result as yet. It is therefore interesting to learn that the first central station working with the three-phase current, recently carried out by the Oerlikon Company, of Zurich, seems to be a thoroughly satisfactory arrangement, and one which is likely to lead to considerable extension in this interesting system. The suitability, in fact, of the three-phase current, both in driving motors for distribution of power as well as for direct lighting, is there demonstrated on a practical scale, the current both running three-phase motors as well as lamps in parallel. The generating station is at Lauffen, six miles from Heilbronn. It contains two three-phase generators of 300 h.p. each, giving a pressure of 86 volts between any two terminals. Only one machine is at present used, the other being kept as reserve. The low-tension current is transformed up at the station to 5,000 volts, and is sent along three overhead wires of 6mm. diameter. The transformation downwards is carried out before entering Heilbronn to 1,500 volts, and thence the current is carried to a distributing station in the centre of the town. From here it is led away to tertiary transformers, 23 in all, connected by feeders to a 100-volt low-tension network. Motors of a total power of 25 h.p. are already installed, and have been working satisfactorily for some time. The station also supplies current for nearly 1,500 lamps of various candle-power, and, besides this, there are also 14 arcs taking eight to ten amperes. This interesting station has yet a considerable reserve of power, but the demand is constantly growing, and the full power will doubtless soon be required. The experimental installation thus receives a practical outcome, and its seeming success will stimulate other projects in the same direction.

Electric Organ.—The magnificent new organ built by Messrs. Abbott and Smith, Blackman-lane, Leeds, to the specification of Dr. Churchill Sibley, and erected in the large concert hall at the Goldsmiths' Institute, New Cross, S.E., containing 60 stops and 3,107 pipes, is blown by means of electricity, the apparatus having been designed and constructed by Messrs. Easton and Anderson, 3, Whitehall-place, S.W., and Erith Iron Works, Kent. This method was adopted as being the simplest and most efficient way of enabling the engine belonging to the institute, and used for pumping, driving the workshop, etc., to supply the power for blowing, and do away with a special prime mover, which would have been for many reasons objectionable. The gear consists of three cast-iron blowing-cylinders 17in. diameter by 24in. stroke, placed side by side on a framework made of rolled joists secured to the concrete floor of the blowing-chamber, which is situated at one end of the gymnasium. Two of these cylinders supply one regulating reservoir, with wind at 5in. pressure, and the third cylinder supplies a second with wind at 10in. pressure, from which suitable trunks are led to the organ. The pistons of the two low-pressure cylinders are worked by a double-throw crankshaft, driven by a worm and worm-wheel, which is enclosed in a cast-iron casing, the worm being connected by a coupling with the spindle of an electromotor capable of giving out ordinarily about 2½ h.p. The piston of the third cylinder is worked by a single-throw crankshaft, with a similar worm gear, and another motor of the same size. The motors always run at an approximately constant speed, and when the reservoirs are full automatic by-passes are opened between the ends of the cylinders, and the air is simply passed backwards and forwards until the reservoirs fall again and shut the by-pass. Switches are arranged with suitable resistances close to the organ keyboard by which either or both of the motors can be started, and which also provide a means of regulating the speed to some extent. The conductors are led from the motors and switches to a space near the engineering workshop, where they terminate in a switchboard having cut-outs and a voltmeter on it, connected to the generating dynamo, which is driven by a countershaft and belts from the workshop shafting. It is capable of giving an output of about 100 volts and 50 amperes. The arrangement works very satisfactorily and requires very little attention.

Royal Cornwall Exhibition.—The sixtieth annual exhibition of the Royal Cornwall Polytechnic Society will be held at the Polytechnic Hall, Falmouth, for five days, commencing August 23rd next. The committee have arranged to make the applications of electricity a special feature at the forthcoming exhibition. They point out to intending exhibitors that up to the present time not much electrical work has been done in Cornwall, save at St. Austell; on the other hand, in many of the West of England towns there is a strong desire for a superior light for both public and private purposes, whilst at Falmouth the question of establishing an electric supply station is now being seriously considered. The Royal Cornwall Polytechnic Society also draw particular attention to the great opening which exists for the introduction of electricity as applicable to the various requirements of Cornish mining and quarrying, and for such purposes as lighting, pumping, hauling, ventilating, drilling, metal refining, and so forth. The society have always given special attention and encouragement to the practical development of Cornish mining, and have, from time to time, given medals and substantial premiums to meritorious inventions and improvements connected with this industry. With reference to rock-drilling machinery, the society claim to have done more than any other institution to introduce power drills into the Cornish mines. From the year 1867 down to the present time, practical tests of rock drills have frequently been made at the society's annual exhibitions, and in many instances medals have been awarded at these competitions. But for the timely introduction of drilling machinery, they think many Cornish mines would have succumbed to the great depression which that industry suffered some years ago. In the belief that there is still room for improvement in the methods of working rock drills, the society offer a special medal for an electrical rock drill applicable to Cornish mining and quarrying. It is intended that the exhibition shall include exhibits in all the various applications of electricity, including: (1) Electric rock drills—in this particular section a medal is offered for the best drill suitable for Cornish mines and quarries; (2) other electric mining machinery and appliances; (3) electric lighting, comprising dynamos, secondary batteries, lamps, fittings, cables, and switches; (4) electric motors for various purpose other than mining; (5) electric bells, telephones, telegraphs, and primary batteries; (6) applications of electricity to medical purposes; (7) other electric exhibits not included in the foregoing classes. No charge will be made for space. There is direct steamship communication with low goods freight between London, Portsmouth, Southampton, Plymouth, Dublin, and Falmouth, twice a week; and between Liverpool and Falmouth weekly. Applications for entry forms and any further information should be made to the hon. secretary of the department, Mr. R. B. Rogers, 10, Gerald-road, Eaton-square, London, S.W.; or to the secretary of the society, Mr. Edward Kitto, F.R.Met.S., The Observatory, Falmouth.

THE CRYSTAL PALACE EXHIBITION.

It is now some time since we referred to the excellent exhibit of the **Edison-Swan Company**. Night after night the large screen (illustrated in our issue of February 19 last) has been lighted, and thousands of visitors will have had impressed upon their minds the fact that the Edison-Swan Company are manufacturers of incandescent lamps. But undoubtedly they claim a wider field, and although the lamp manufacture may be said to be their leading article, they also manufacture holders, switches, and other paraphernalia pertaining to incandescent lamp installations. The accompanying illustrations show some of their switches. Fig. 1 is a branch switchboard fitted with "chopper" switches and double-pole fuses. It is mounted on a slate base, and the whole enclosed in a teak case with glass over, so that it can be closed and locked. Fig. 2 shows a two-way switch with the fuses on a slate base, and Fig. 3 shows a two-circuit switch, also on slate. Fig 4 shows the Edison meter, which has so often been fully described that it is only necessary to recall it to the recollection of our readers. It is an electrolytic meter, and one that has not found great favour on this side of the Atlantic. This meter is provided with a thermostat in the shape of an incandescent lamp, which comes into action when the temperature of the meter falls below a certain point, also a compensating resistance to keep the resistance of the shunt circuit constant through varying temperatures. Fig. 5 shows a new form of key holder with a fibre base. These illustrations all explain themselves, and, as we say, must be taken as typical of this company's work outside the lamp manufacture.

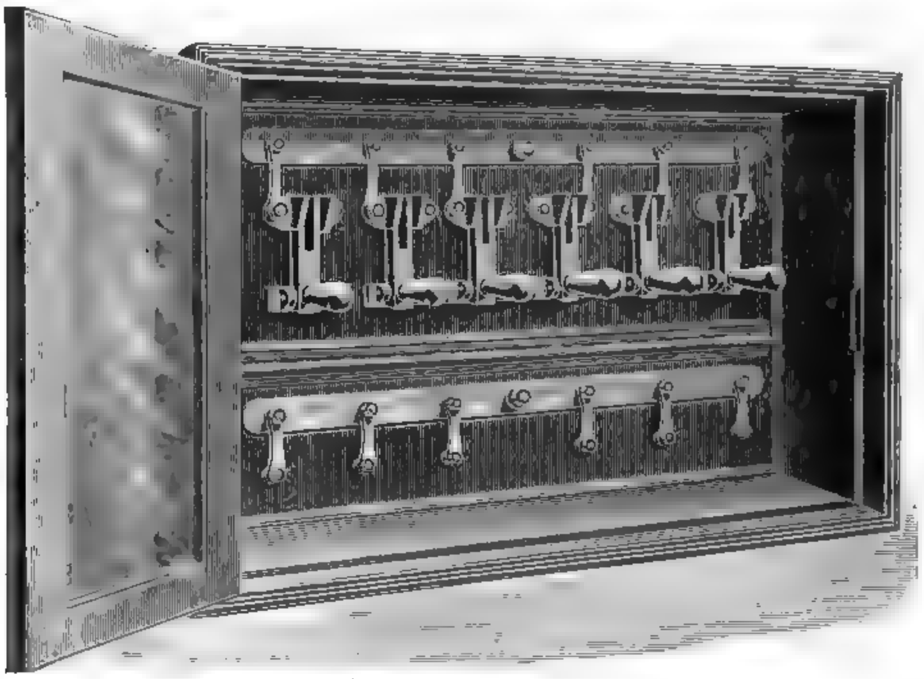


Fig. 1.—Edison and Swan Branch Switchboard.

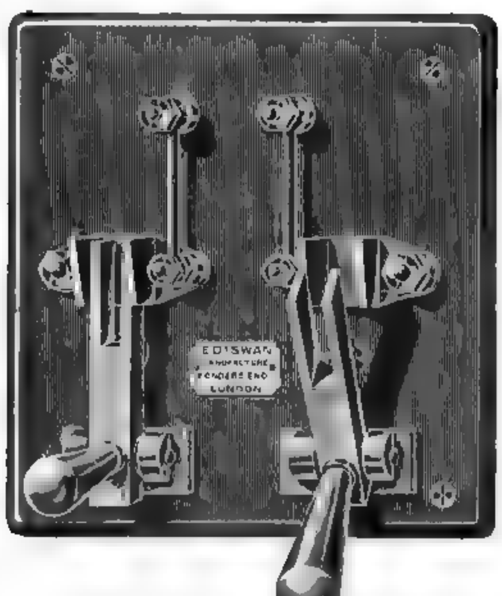


Fig. 2.—Two-way Switch.

Most of the exhibits at the Crystal Palace are interesting both to the public and to electrical engineers from the final result or installation point of view—we see the machinery, the apparatus, the instruments as they are constructed and will be used in actual work. There is one exhibit, however, that of **Messrs. Charles Churchill and Co., Limited,** which is more particularly interesting to engineers from the manufacturing point of view, in the shape of a large number of the latest and most approved kinds of machine tools, automatic or otherwise. A careful inspection of the tools in action at their stand will result in a vivid appreciation of the enterprise, energy, and ingenuity which the American manufacturers whom Messrs. Churchill represent have put into the production of this class of goods. Since the remarkable display of automatic watchmaking machinery at the Inventions Exhibition some years ago, manufacturers have become accustomed to the varied ingenuity of the automatic machine tools, large and small; and at the Crystal Palace we have a display, smaller, perhaps, but to the electrical engineer far more important, in the lathes, drilling, milling, and tooling machines for heavy work, all the more interesting in that they are there driven by power electrically transmitted to electric motors

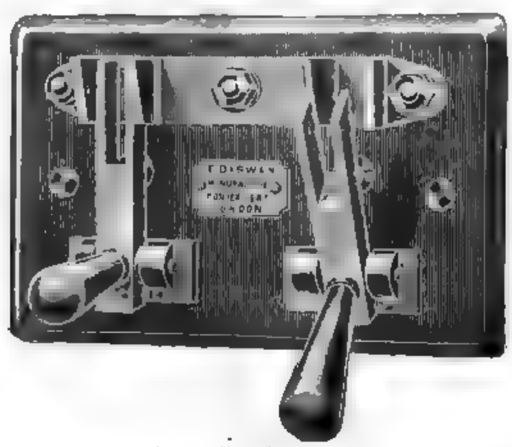


Fig. 3.—Two-circuit Switch.

The new tool-room automatic milling machine shown by

Messrs. Churchill and Co., the product of the Brainard Milling Company, of Boston, is a marvel of compact usefulness. This machine is designed with special reference, as its name implies, to tool-room purposes, being most conveniently arranged for every variety of work incident to the tool-room, making milling cutters of every kind, cutting twist drills, fluting taps and reamers, cam cutting, die sink-

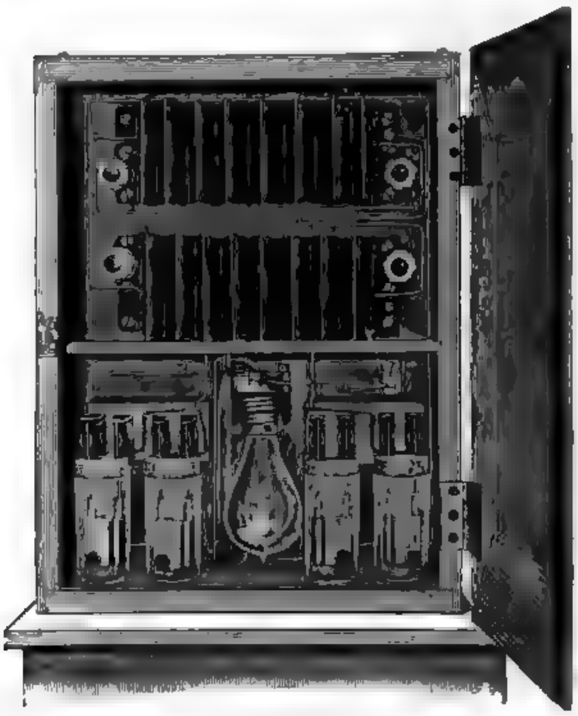


FIG. 4.—Edison Meter.

ing, nut and bolt finishing, cutting of spur, bevel, and worm wheels, and the hundred other necessary purposes. It cuts spirals automatically, both right and left hand, the full length of machine feed, and of all sizes and pitches. The work table swivels in both directions to an angle of 45deg., and the feed work, centrally driven, is not affected by the position of the table, which feeds backward or forward

FIG. 5.—Key Lampholder.

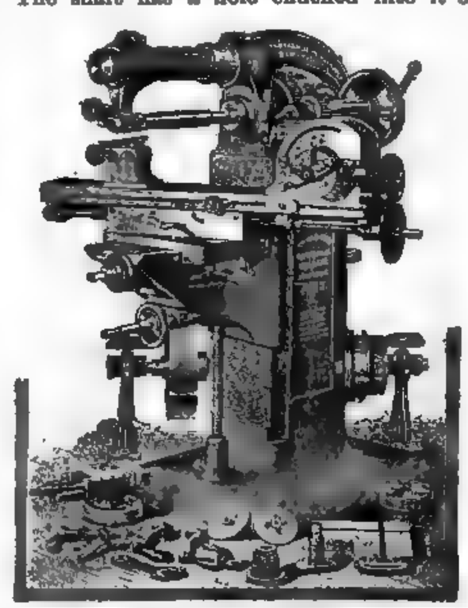
without changing the direction of belt. The swivel carriage rotates on a central bearing, and, when adjusted, is bolted to the lower half which traverses the knee, thus avoiding the usual weak centre joint held by only a single set screw. Each size except the smallest is provided with Brainard's head and back centre, the most convenient dividing centre eased on a milling machine. It has an overhanging arm for outside centre support, fitted for quick removal. The dividing head combines the directness of a notched dial with the accuracy of a worm wheel. Two systems are combined—one for cutting gears, and the other for small work or for finishing.

The Hendey shaping machines, which we also illustrate, are adapted for tool-making and accurate die-work. The feed is automatic in all directions. The driving movement is by patent friction, enabling the cutter-bar to work up to a line and reverse without jar. The length of stroke can be changed instantly while in operation, and the reversing motion is very simple, and not liable to get out of order. The table can be adjusted to plane taper-work, and space

Hendey Shaping Machine.

is provided under the cutter-bar for cutting key seals and other similar work.

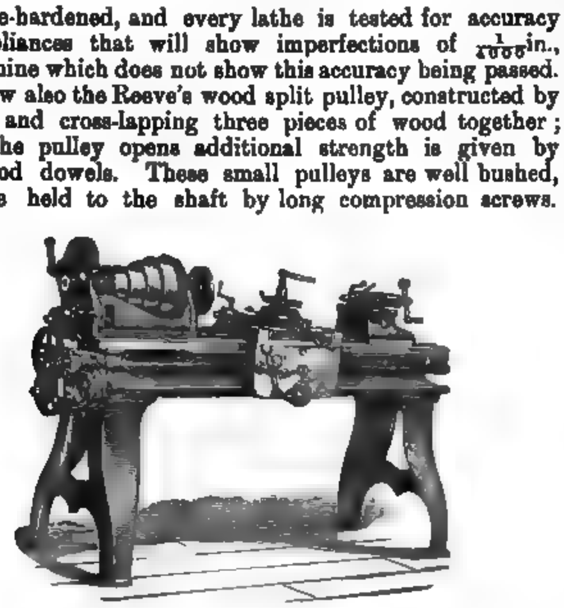
Another interesting and extremely useful machine is Flather's screw-cutting hollow-spindle engine lathe. This lathe is made to gauge, and its parts are interchangeable. The headstock has a hammered steel spindle and th bearings run in hard bronze boxes, which can be renew easily. The shaft has a hole chucked into it 3in.



Brainard Toolroom Miller.

and forms a bearing for the feed-rod, which is telescoped into and revolves freely in it. On the feed-rod is a clutch to interlock with the clutch on the short shaft in use. The screw is fitted in the upper hole of the same casting, and is connected when in use by slip gear. The lathe is compact, it admits of better control of the feed, which can be changed from belt to gear, and from coarse to fine, or the reverse, very quickly. A finishing cut from the finest up to $\frac{3}{8}$in. per revolution can be taken. All nuts, wrenches, and screws on the lathe

are case-hardened, and every lathe is tested for accuracy by appliances that will show imperfections of $\frac{1}{1000}$in., no machine which does not show this accuracy being passed. We show also the Reeve's wood split pulley, constructed by glueing and cross-lapping three pieces of wood together; when the pulley opens additional strength is given by hardwood dowels. These small pulleys are well bushed, and are held to the shaft by long compression screws.



Flather Screw-cutting Machine.

The above are a few out of many exhibits of machine tools and appliances which Messrs. Churchill make a speciality. Of the immense variety and number of the full assortment of tools kept by the firm, probably few persons have any adequate idea. A catalogue, one of the handsomest obtainable, has just been issued by this firm, and can be obtained from the offices, 21, Cross-street, Finsbury, E.C. It consists of over 300 large pages, and

Wood Split Pulley

when we say that there are often half-a-dozen or more beautifully-finished woodcuts illustrating all kinds and sorts of tools and machines on every page, the extent and variety of the business can be appreciated.

AMPERE-CENTIMETRE—A MEASURE OF ELECTRO-MAGNETISM.*

BY CARL HERING.

It appears from the following deductions that an electric current multiplied by the length of the circuit will represent the number of magnetic lines of force generated by this current; or, in other words, that the number of lines of force generated by a current can be measured by the product of the current and the length of its circuit. A unit current passing through a unit length of circuit, appears to generate a certain fixed and constant number of lines of force. This, of course, has reference to the electromagnetism of the current itself, and does not include the influence of any magnetic bodies in the neighbourhood.

First of all it is necessary to show that amperes multiplied by length will give a unit of a similar nature to magnetic lines of force or flux, in order to show that an equivalent between the two may be given without transgressing the laws of physics. This may be shown conclusively by the aid of the dimensions of these units in the absolute system. The dimension of current is $m^{\frac{1}{2}} l^{\frac{1}{2}} t^{-1}$, while that of magnetic flux (that is, number of lines of force, not their density per square centimetre usually represented by H or B, nor the intensity as it is sometimes called), is $m^{\frac{1}{2}} l^{\frac{3}{2}} t^{-1}$. It will be seen that the former multiplied by a length gives the latter. This shows conclusively that ampere-centimetres, or ampere-feet and magnetic flux are units of the same kind and can therefore be equated.

Having determined this point, the following appears to show that every unit length of a circuit conveying one ampere, generates a fixed and constant number of lines of force. Using absolute units, the intensity of magnetisation (or number of lines per square centimetre) at the centre of a circle of one turn, according to the well-known formula, is

$$H = \frac{2 c \pi}{r},$$

in which r is the radius in centimetres and c is the current.

Now the intensity of the field is different in different parts of the area enclosed by the circle, being greatest nearest to the wire, but it may be assumed that in all circles, large or small, the ratio of the intensity at the centre to the average intensity in the whole circle is a constant. Let this ratio be called K, then the total number of lines will be equal to the intensity at the centre multiplied by the area and by K; that is,

$$M = \frac{2 c \pi}{r} \times \pi r^2 \times K = 2 c \pi^2 r K.$$

By dividing this by the circumference will give the number of lines per unit length of the circuit

$$2 c \pi^2 r K \div 2 \pi r = C \pi K,$$

or per unit of current, this is equal to π K. It will be seen that this is a constant, and is independent of the radius, r. This means that the number of lines per unit length and per unit current is the same for all circles, and therefore also for a straight line, which is a circle of infinite radius.

From this it appears that, knowing this constant number of lines per ampere per centimetre or foot, the calculation of the total number of lines generated by any circuit or coil would merely be the product of the current, the length of the circuit, and a constant.

It should be remembered, however, that this deduction supposes theoretical conditions; that is, a filamentary wire having no appreciable diameter. How far the size of the wire introduces an error remains to be determined. At all events, if the diameter of the wire is small as compared with the diameter of the coil, and specially if the coil, as it usually does in practice, contains iron which appears to concentrate the lines in it, and therefore probably attracts those circulating in the body of the wire itself, it may doubtless be assumed that the ratio of the flux in two coils would be equal to the ratio of their ampere-feet, which proportion might be of use in dynamo construction.

The above deductions were made by the writer a number of years ago, but as they did not appear to agree with some existing laws at that time, the matter was laid aside. It seems, however, that subsequently some dynamo builders have advocated and used this system of calculation in preference to the other, and it was therefore thought best to publish this proof, hoping that some others well informed on this subject might point out the discrepancies, if any, and perhaps show the extent of the application in practice of calculating the magnetic flux of a current from the ampere-centimetres of the circuit.

* Paper read at the meeting of the Electrical Section of the Franklin Institute, held May 3, 1892.

ELECTRICAL DISTRIBUTION BY THE NEWCASTLE-ON-TYNE ELECTRIC SUPPLY COMPANY.*

BY A. W. HEAVISIDE AND R. C. JACKSON, MEMBERS.

Preliminary.—The town of Newcastle is supplied with electrical energy by two companies, operating different districts, and distinct from one another. These are the Newcastle and District Company, using Parsons turbines, supplying the southern and western portions of the town, and the Newcastle Electric Supply Company (the company with which we are connected), supplying the northern and eastern portion. This paper deals with the distribution of

* Paper read before the Institution of Electrical Engineers, May 26, 1892.

electrical energy by the Newcastle-on Tyne Electric Supply Company, Pandon Dene, it being thought that the members of the Institution would find interest in an account of the methods of working, and of the technical and financial results obtained during the first financial year of the company's operations.

The system employed is a high-pressure one of 2,000 volts, alternating current, with separate transformers in the consumers' premises, the price charged being 4½d. per Board of Trade unit. The company was formed on the 7th January, 1889. Some questions having been raised upon legal points by the local authorities, the whole of 1889 was employed in negotiating the license. These negotiations were more prolonged than usual, and it was not until the close of November that a provisional arrangement was entered into, enabling the company to proceed with the street works in anticipation of the Board of Trade license, which was not received until March 21st, 1890.

Site.—Eligible sites for the establishment of a central station were found to be limited in number; however, at Pandon Dene, some vacant land was eventually selected, which appeared to have some advantages in its favour. The business quarter is to the south and the residential quarter to the north, thus facilitating the whole of the company's operations being transacted from one point. The site is also alongside the sidings of the Blyth and Tyne branch of the North-Eastern Railway, which taps the Northumberland steam coalfield. There is ample room for extension, as the company's land occupies a space about 127ft. wide and 436ft. long, parallel with the railway. The absence of dwelling-houses in the immediate vicinity of the works avoids difficulties which might arise from the vibration caused by machinery in motion. Against these advantages must be set the want of cheap water for condensing purposes. The "supply company's" water is taken from the intermediate service of the local water company, the average cost per 1,000 gallons being 9·78 pence.

Buildings.—The dominant idea in laying out the station buildings was to so arrange them as to reduce any reconstruction to a minimum; the erection of each successive section being carried out without interruption or disturbance to the plant already fixed. At the present time two sections have been built, enclosing a space 119ft. by 74ft. by 13½ft. high to the top of the girders. This space is covered by means of a light iron lantern roof, supported upon wrought-iron girders and cast-iron pillars, resting on concrete footings. The openings between the pillars are filled up with common brick, lined on the inside of the engine and dynamo room, to about 7ft. 6in. high, with varnished pitch-pine. A brickwork partition separates the boiler-house, which is 74ft. long by 55ft. wide, from the engine and dynamo room, 74ft. by 63ft. 6in. Two chimney-stacks have been built, one at either end of the main boiler flue, which runs along the boiler-house side of the partition wall. One chimney has a sectional area at the top of 30 square feet, and is 85ft. high; the other chimney measures 23·5 square feet at the top, and is 110ft. high. Great care had to be taken with the foundations, as the natural bed is no less than 75ft. below the present ground-level, the intervening soil being made ground.

Contents of Buildings.—The station at present contains plant capable of a total output of 600 kilowatts, in the following units: One 250-kilowatt alternator, three 100-kilowatt alternators, one 50-kilowatt alternator—each machine being rope-driven by means of a separate engine. The year's operations dealt with in this paper were, however, carried out by three 100-kilowatt alternators and one 37½-kilowatt alternator.

The general arrangement of the machinery in the station consists of three double flued Lancashire boilers, manufactured by Messrs. Robey and Co., Lincoln. General particulars: Working pressure, 120lb. per square inch; all plates of the best Siemens-Martin mild steel; diameter of shell, 7ft.; length of boiler, 28ft.; boiler shell plates, $\frac{9}{16}$in. thick; flue plates, $\frac{9}{16}$in. thick; end plates, ⅝in. thick; number of flues, two; diameter of flues, 2ft. 9in.; 12 Galloway tubes; heating surface, 750 square feet; grate area, 38 square feet. Two of these boilers have been fitted with Messrs. Bennis's mechanical stokers, and one of them with Messrs. James Proctor's stoker. The figures of a test with these stokers will be given later in the paper. N.B.—Two additional boilers have been fixed for the extensions now proceeding, fitted with Proctor's stokers.

Engines and Dynamos.—One vertical compound engine by Robey and Co. General particulars: Cylinders, 11in. and 18in. diameter, by 12in. stroke; speed, 200 revolutions per minute; flywheel, 6ft. diameter, grooved for eight 1in. ropes; power, economical load, 75 i.h.p., with 100lb. steam pressure at the engine stop-valve. The engine is fitted with automatic expansion gear, and with Meyer's adjustable cut-off on the L.P. cylinder. This engine drives a 37½-kilowatt Mordey-Victoria alternator with an E.M.F. of 2,000 volts effective at a speed of 650 revolutions per minute.

Three compound horizontal fixed engines by Messrs. Robey and Co. General particulars: Cylinders, 16in. and 26½in. diameter, by 36in. stroke, fitted with the Rowland-Richardson trip valve gear; speed, 73 revolutions per minute; flywheel, 15ft. diameter, grooved for 12 1½in. ropes; weight of flywheel, five tons. N.B.—The flywheels are being weighted with an additional five tons each. Power, economical load, 175 i.h.p.; maximum working load, 240 i.h.p., with 110lb. pressure of steam on the engine side of the stop-valve.

These engines each drive a 100-kilowatt Mordey-Victoria alternator at a speed of 430 revolutions per minute. Each alternator is excited independently by means of an exciter connected direct to the alternator shafts. Another engine of the same class has lately been erected for the purpose of driving a 250-kilowatt Mordey-Victoria alternator. General particulars: Cylinders, 19½in. and 33in. diameter, by 40in. stroke; speed, 70 revolutions per minute; flywheel, 17ft. diameter, grooved for 13·1¾in. ropes; weight of flywheel, 15 tons; power, economical load, 400 i.h.p.; maximum load, 500 i.h.p.; with 110lb. of steam on the engine side of the stop-valve.

Water-Feed Apparatus.—One Glo'ster Duplex pump, to throw 800 gallons per hour; two Holden and Brooke's exhaust injectors, fitted with auxiliary live-steam nozzles, each delivering 600 gallons per hour at about 170deg.F.; one additional injector, as above, for the plant extensions now going on.

Switchboard.—Several forms of high-tension switches have been tried, but none have been found quite satisfactory. A permanent switchboard is now being designed to suit the company's requirements.

Use of Plant.—For the light day and night load, the high-speed vertical engine is employed, the other machinery being brought into use as the service requires. The circuits, four in number, are coupled together or separated as the load varies.

Distribution.—The electrical energy is distributed by means of four main circuits of concentric cable, insulated with vulcanised rubber, drawn into cast-iron pipes, of which nearly 10 miles have now been laid. The system adopted is that of one pipe, one cable, and means are provided at the street boxes by which the service may be treated either as a radial one or as a network, without disturbance to the insulation.

Cables.—The inner and outer conductors of the concentric cables are separated at each junction or lead-in, and are terminated by means of metallic washers, which are screwed down and clamped together on porcelain insulators. The system of mains is thus quite flexible, and changes in connection are made as easily and expeditiously as at a Post Office test-box.

Street Boxes.—The street boxes are built of brick, set in cement, and protected from surface leakage by double cast-iron covers.

Transformers.—The transformers employed are, in general, those of the Elwell-Parker design, varying in capacity from 1 e.h.p. to 10 e.h.p., and are usually placed in cellars, upon the premises of the individual consumers. The Mordey, Kapp, Swinburne, and Tyne transformers are being experimented with.

Meters.—The "Shallenberger" is in general use, with some Aron, Ferranti, Thomson-Houston, and Frager meters under trial.

Working Results.—As already stated, the company did not commence the supply of electrical energy until 1890

and then only experimentally. It was simply a year of construction and organisation. Nevertheless, the progress diagram, Fig. 6, which accompanies this paper cannot fail, it is thought, to be of interest, as showing the comparative rapidity with which the service developed within the area of the city covered by the operations of this company, so soon as the preliminary delays were overcome. Commencing from the 1st of January, 1891, it will be seen that by the end of the year the lamps installed equalled 431,000 watts, rising from 253,000 at the beginning of the year, or a mean of 342,000 watts. During the year 244,470 units were metered at the consumers' premises. The units metered at the station amounted to 327,821, showing a loss from all causes in distribution of 25·4 per cent. Dividing the total watt-hours sold during the year by the mean capacity in watts installed, we get a result of $\frac{244{,}470 \times 1{,}000}{342{,}000} = 714$ as the average lighting hours per annum. That is to say, our annual output was equivalent to running all the lamps installed for 714 hours—practically two hours per day per lamp.

Character and Class of the Installations.—With the exception of the post office and the public library, the installations are small rather than large, there being no hotels and few restaurants, but mainly shops, offices, and private houses; the net result being a low load factor of 8·16 per cent. By the term "load factor" we mean the ratio of the units sold to the units that could be sold if all the lamps were always on. Thus,

$$\frac{\text{Metered watt-hours} \times 100}{\text{Mean watts installed} \times \text{number of hours in the year}}$$

$$= \frac{244{,}470 \times 1{,}000 \times 100}{342{,}000 \times 8{,}760} = 8{\cdot}16 \text{ per cent.}$$

Price.—The price charged by the company has been described as the "phenomenally low one of 4½d. per B.T.U." (less 5 per cent. discount). With gas costing only 1s. 10d. (less 10 per cent. discount) per 1,000 cubic feet, it is quite evident that, whatever advantages the electric light possesses over gas, it would be difficult to obtain a higher price than 4½d. Believing that at this price a profit could be earned, we recommended the company to charge this low figure, and we may say that our anticipations have been realised. The problem was, therefore, how to produce the unit at a low cost, and to obtain custom in sufficient amount to earn a fair dividend upon capital invested. N.B.—It may be objected that the period of work upon which this statement is made is too limited to inspire confidence; but we venture to think that, once having overtaken our establishment charges, the commercial prospect will improve rather than the reverse.

Cost of Production: Coal.—The company uses small steam coal, supplied and delivered by the Gosforth and West Moor Coal Company at the average price, over the year, of 5s. 10d. per ton. Since 2,300 tons of coal were used, the quantity of coal burnt per unit sold amounted to $\frac{2{,}300 \times 2{,}240}{244{,}470} = 21{,}074$lb., at a cost of 0·663 of a penny. It is to be noted that this coal bill includes all consumption for trial runs of new plant, various testing work, banking and making up of fires, steam heating to offices, and for all other purposes. We consider that it would be interesting, and of value, if a relation could be established between the result as given above and the results: (1) If a standard Welsh coal had been used; (2) with water-tube boilers, burning small steam coal, with mechanical stokers; (3) with water-tube boilers, burning Welsh coal, both (2) and (3) being worked under the same conditions with respect to the load factor as in our own case. For the purpose of facilitating such a comparison, we give analyses of Welsh coal and of that used by us—as the theoretical value per pound of coal, showing a difference in favour of Welsh coal of 31 per cent.

	Welsh coal.	Gosforth and West Moor.
Carbon	14 500 × ·84	14·500 × ·649
Hydrogen	62·032 × (·046 − ·O/8)	62·032 × (·053 − ·O/8)
Sulphur	4·032 × ·015	4·032 × ·0124
Ash per cent.	4·9	13·44
Heat units	14,833	11,300
Theoretical evaporative efficiency in pounds of water from, and at 212 deg. F., deducting ash in both cases	15·45	11·75
Or including ash	14·69	10·17

It may here be remarked that the difference in cost between the best Newcastle coal and that used by us is generally about 50 per cent. It is quite evident from the foregoing analyses that, in order to compare our results as to weight of coal per unit sold with London figures, a fair-sized divisor would be required. Our want of sufficient data does not enable us, unfortunately, to state what that divisor ought to be. We are in hopes of being enlightened on that point during the discussion on the paper.

Water Account.—All the water consumed at the station for all purposes was measured by a Kennedy water-meter, which registered 2,922,000 gallons for the year. To arrive at the amount of the water evaporated, a deduction of 10 per cent. is made to allow for such items as washing out and filling up of boilers, cleaning down lavatories, buildings, etc. The allowance being made, we have, as the total water evaporated to steam, 2,629,800 gallons, or a water consumption per unit sold of $\frac{2{,}629{,}800 \times 10}{244{,}470} = 107{\cdot}5$lb., at a cost of 0·1053 of a penny per unit generated, or at the station = 107·5 × 0·75 = 80·63lb. The average evaporation of the boilers thus becomes—

$$\frac{\text{Pounds of water per unit sold}}{\text{Pounds of coal per unit sold}} = \frac{107{\cdot}5}{21{\cdot}074} = 5{\cdot}1\text{lb.}$$

We have obtained an evaporation of from 7lb. to 8lb. of water per pound of coal with the boilers working under the best conditions; the difference, 7·5 − 5·1 = 2·4lb., is accounted for principally by banking of fires at times of low load and heating up of standing engines.

Oil.—Oil averaged 0·0014 gallon, at a cost of 0·044 of a penny per unit sold.

Waste, Sweat Cloths, and Sundry Stores.—These work out at 0·55 of a penny per unit sold.

Repairs.—Repairs to buildings and plant at the station amount to 0·2480 of a penny per unit sold. This sum includes everything necessary to maintain the machinery at its full efficiency, and also to carry out some small alterations that experience suggested for the improvement of the plant.

Labour and Supervision.—It is found that at the period of maximum load the staff necessary to run three 200-h.p. engines and three 100-unit alternators consists of one station assistant, one engine driver, and one stoker. Three sets of men are employed, arranged in shifts of eight hours each, with one hour overlap for cleaning, oiling, etc. The cost of the service, inclusive of proportions of the manager's and secretary's office charges, works out at 1·9462 pence per unit sold. The cost of all service external to the station over nearly 10 miles of mains, leads-in, transformers, meters, etc., is 0·2817 of a penny. To these figures have to be added the general charges, which amount to 0·6807 of a penny. Summarising the cost, we have—

	d.	d.
Coal	0·663	
Oil	0·0440	
Petties	0·0579	
Water	0·117	: 0·8819
Repairs	0·2480	
Labour anda upervision	0·8163	
External	0·2817	
General (rent, rates, taxes, law, sundry expenses)	0·6807	: 2·0267
Per unit sold		2·9086

Capital.—When the capital account is closed for the works in progress, it is estimated that for each kilowatt installed an expenditure of £50 will have been incurred. This result will in all probability be reached by the end of the present year, when, as shown by the progress diagram, the plant erected will be capable of working at 600 kilowatts, or of dealing with 800 kilowatts wired, leaving one-fifth reserve plant.

Plant Efficiency.—We shall now consider some of the points in connection with the plant efficiency, it being always borne in mind that the results actually obtained

are over a period of 12 months, with a mean load factor of 8·16 per cent.

Boilers.—With a view to the economising of labour, and to abate the smoke nuisance as far as possible, the boilers were fitted with mechanical stokers, as already stated. The following is a table showing the result of a test between the two classes of stokers now in use :

STOKER TESTS, JULY 5 AND 18, 1891.

Description of firing.	Time in hours.	Gallons of water evaporated.	Coal consumed in pounds.	Pounds of water per pound of coal.	Per pound of combustible. From and at 212deg. F.
Bennis stoker and bars.	3¼	1,750	2,492	7·02	8·29
Proctor „ „	3¼	1,920	2,352	8·16	9·64
	—	9·7 %	6 %	16·2 %	*

* In favour of Proctor's stoker.

We have found the boilers supplied to us to be each capable of generating steam for 240 i.h.p. at the engine cylinders without due forcing. The boilers are generally fed through exhaust steam injectors, assisted by auxiliary live-steam jets, the average temperature of the feed-water being about 170deg. F.

Water.—The water used is of a medium quality, having 15deg. of hardness.

Engines.—The engines are fitted with steam-jackets in both the high-pressure and low-pressure cylinder. The steam, on its way to the low-pressure cylinder, passes through an intermediate receiver, where its temperature is raised, and probably some of the contained water re-evaporated to steam, by means of a coil of piping, through which a passage of live steam is maintained.

Dynamos.—The directors have been much pleased with the satisfactory reports which have come in from the consumers regarding the steadiness of the light, which is in part due to the good governing of the engines, and to the incidental advantage that the Mordey-Victoria alternators possess in the momentum acquired by the revolving field magnet. Improvements are being introduced as suggested by experience, and the 250-unit alternator now in course of erection is fitted with an outer bearing. The mechanical construction of the armatures also improves with each succeeding make. The oiling arrangements, by means of small pumps driven from the alternator shafts, have proved very effective.

Station Output and Efficiency.—The E.M.F. of the dynamos is measured by Cardew voltmeters, and the current by means of Evershed ammeters, the readings being taken every half-hour and posted in the engine-room day-book. The correctness of the various ammeters is checked from time to time by comparison with a Siemens dynamometer, which is again checked in the laboratory of the local College of Science. The principal data are as follows :

Units metered at the consumers'	244,470
Station units	327,821
Loss in distribution	25·4%
Total running hours at the station	7,504
Indicated horse-power hours	939,500

Average indicated horse-power per hour .... $\frac{939{,}500}{7{,}504} = 125{\cdot}2$

Units per running hour (at the station) .... $\frac{327{,}821}{7{,}504} = 43{\cdot}686$

Average watts per indicated horse-power per hour $\frac{43{,}686}{125{\cdot}2} = 348$

Weight of water per indicated horse-power per hour, inclusive of radiation and condensation losses .... $\frac{2{,}629{,}800 \times 10}{939{,}500} = 27{\cdot}91\text{lb.}$

Average commercial efficiency of engines and dynamos.................. $\frac{\text{Total E.H.P. for the year}}{\text{Total I.H.P. for the year}} \times 100 = 46{\cdot}6\%$

Parallel Working.—Trials have been made to work in parallel, with only a partial success. The trials called attention to the varying angular velocity of the engine fly-wheels, due to the early and quick cut-off of the trip valve gear. We hope to obtain successful results by increasing the weight of the flywheels, which work is now in progress; also by increasing the elasticity of the drive by the use of spring pulleys arranged on the principle of the transmission dynamometer, in place of the ordinary pulley. As a uniform turning effort is the end to be aimed at, we believe that the steps we are taking will accomplish that result.

Distribution. — The installations on the consumers' premises, as shown in the progress diagram, amounted to 431,000 watts on December 31st, 1891. The nominal transformer capacity supplying the above was 391,000 watts, or an excess of installed watt capacity to transformer provision of 9 per cent. The percentage of excess has been reduced by the recent extension of small shop-lighting, etc.; it had previously been run up to as high as 25 per cent.

The object we had in doing this was to keep the average transformer efficiency as high as possible, and at the same time to avoid undue fall of pressure in the service. That this course may be safely carried out, if we discriminate between those consumers who burn all their lamps simultaneously and those who never by any chance do so, is supported by an examination of the progress diagram. It will be observed that the average proportion of lamps lighted at any one time to lamps installed, is about 45 per cent. Taking the extreme case on the sheet, we have a proportion of 28 per cent. excess. We find the average lighting hours per annum of the various classes of consumers on the company's mains to be as follows :

Restaurants.	Shops.	Offices.	Private houses.
1,563	459	499	344

As previously stated, the distribution losses from all causes average 25·4 per cent. over the year. The loss is incurred from two sources—transformer and line losses. Weekly observations are taken, by means of Lord Kelvin's milli-ampere-meter and a low-reading Siemens dynamometer, for the purpose of checking and comparing these losses.

Summary.—Summarised, the chief results embodied in this paper are :

1. Load factor (as per definition)	8·16 %
2. Loss in distribution	25·4 %
3. Average lighting hours per annum	714
4. Coal bill per unit sold	21·074lb.
5. Water = 107·5 + 10 per cent. for water deducted for efficiency results	118·2
6. Pounds of water evaporated per pound of coal, banking, etc., inclusive	5·1lb.
7. Water consumption per indicated horse-power hour	27·91lb.
8. Engine and dynamo average efficiency	46·6 %

General Conclusions.—Much discussion has taken place on the merits of the various methods of supply. We have had to consider the matter from a purely commercial point of view, having regard only to giving an efficient service, at the least cost, and quite without prejudice in favour of any particular system or mode of working. That the results have been obtained by the use of separate transformers in the consumers' premises, without a secondary network, by machinery constantly running, with no storage except the coal heap, gives some ground for believing that in alternating-current distribution there exists a means of supplying the public with electric energy, and of meeting parliamentary and other obligations, at a price which is satisfactory to the public, and affords investors a reasonable interest on their capital. It may be stated to those interested in sub-transformer station distribution that the average losses in direct distribution over this year have been reduced from 25·4 to 19·5 per cent., and as the load increases it is hoped that further reductions will take place. Also, the total cost of the unit sold equals 2·9086 pence, which includes everything except directors' fees and legal charges.

Railway Yards.—There is a great deal more work in arc electric lighting that might be done than is yet carried out for railway companies' goods yards and open shunting places. Probably in many cases only a definite scheme or an application in the right quarter is needed for considerable contracts to result. The Midland Railway have recently set a good example in their Leeds and other stations in the introduction of extensive electric plant.

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'BUS LIGHTING.

It goes without saying that the more ways found for the consumption of electrical energy, the better it will be for central stations. It matters little whether current is supplied to turn a sewing machine, cook a chop, or charge a battery—the main object is to increase the demand. The new departure in 'bus lighting may have no immediate effect upon the demand from central stations, but if such lighting becomes general such demand will arise. We sometimes rashly accuse men in responsible positions for being too conservative, and showing little desire to try new-fangled inventions. When the matter is thoroughly examined, it may be found that, so far from being averse to introduce improvements, larger or smaller sums of money, and much time and trouble, are spent in testing the said improvements. It has been so in the case of 'bus lighting. No one admires the existing stinking oil lamp, but till quite recently all the attempts to get some other practical light in its place have ended in failure. As is well known, most of the omnibuses are lighted under contract with Mr. Willing. That gentleman is keen enough to understand that improved lighting may be satisfactory in more ways than one, and for years past has had under trial various methods by means of gas and electricity. Primary and secondary batteries have been tried and failed, till Mr. Niblett, manager of the Lithanode and General Electric Company, in conjunction with Mr. Hymns, manager for Messrs. Willing, solved the problem. The battery used is a five-cell battery, constructed of FitzGerald's lithanode plates, fitted into a box. The terminals are led to two contact-pieces on one side of the box. The battery so arranged is put into a well under the driver's feet, in which are two contact-pieces leading to a 5-c.p. Edison-Swan lamp. So far, the battery has been under a continuous practical test for about three months, with results so satisfactory that a contract has been entered into to supply, and electrically and mechanically maintain, the lights in the omnibuses upon one of the London Road-Car Company's routes. If this extended experiment is satisfactory, the intention is to fit up the greater number of omnibuses plying in our streets with the electric light. Such an extension would mean a fairly large demand of current at various convenient centres in this huge metropolis, as it would be extremely inconvenient to cart the batteries backwards and forwards to one place for charging. The success of batteries under the rough conditions which hold in omnibus traffic ought to give us fresh heart that more extensive use will be made of them in self-contained tramcars. In the latter case, however, to the mechanical difficulties are added the difficulties due to the requirements of an extremely rapid discharge at varying intervals of time. From the æsthetic point of view, the improved method of lighting omnibuses will be heartily welcomed. These vehicles are at no time palaces of comfort, but there are times when, what with the evil smell from the lamps, the flickering light, added to other discomforts, a seat in an omnibus means a minor taste of purgatory.

PAINS AND PENALTIES.

Boots—these necessary articles of human attire seem destined to become somewhat conspicuous, so far as we are concerned, for, as our readers will see, we are threatened with the direst pains and penalties of the law unless we retract all we said in our note on page 389. The law of libel is so very peculiar that it may be we are heaping coals of fire upon our heads by referring to this case. Many of our readers will recollect the man who was called to account for his libel upon a woman—"She was ten years older than she looked!" Under threat of condign punishment he retracted—"She wasn't ten years older than she looked." It is our misfortune to be unable to take in all this rigmarole about "odic force" and "odic magnetism." If business-men will tamper with things they know not of, they must expect some sharp criticism. We have nothing to retract from what we have said. The people who are led to consider the buying of boots because of some high-sounding farrago and scientific nonsense have to depend upon technical journals for words of warning and advice. Most emphatically, the putting of a magnet in the heel of a boot is no more efficacious in curing bronchitis or in renewing brain power than the rubbing of the head with a piece of wood would be. Mr. Randall is depending upon the ignorance of a purchasing public in order to obtain a higher price for something that has absolutely no value of the kind he puts upon it. A good boot may be of immense value in keeping the foot dry, and so preventing a possibility of bronchitis; but that a magnet in the heel of the boot will cure the bronchitis is quite another matter. The moment Mr. Randall will prove the efficacy of the magnet, so soon we will apologise to any extent he pleases. There are plenty of men we know to whom a renewal of "brain power" would be a godsend. Perhaps we are given a little that way ourselves. What a grand chance for scientific investigation! Will Mr. Randall supply the boots? we will supply the corpuses. We shall also be happy to insert any communication from Mr. Randall that tends to prove him correct in his statements. Our aim is to obtain facts, and not to be satisfied with the exuberant outpourings of the imaginations of quasi-scientific investigators.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE EDITOR REQUESTED TO RETRACT.

SIR,—The attention of my client, Mr. Henry Edward Randall, of Northampton and of London, has been called to a most offensively-worded article with reference to the mode in which he conducts his business, contained in your issue of the 22nd ult., under the heading "Electroforce Boots," and although the article would have no weight whatever with persons who had full knowledge of my client and of the methods pursued by him in the large and successful business which he has carried on for upwards of 20 years, yet it would undoubtedly most gravely prejudice him with persons who had not the benefit of this knowledge, and who would no doubt, after reading your article, be careful not to have dealings with a tradesman whom you stigmatize as resorting to "dodges" in carrying on his business, to practising on the "gullibility" of the public, and to countenancing measures for selling his goods which "sail perilously near false pretences." Your article, moreover, winds up by a statement that the way in which my client is introducing to the public a new boot, which is called the electroforce boot, is "unworthy the name of a respectable tradesman."

Now these are grave and libellous statements, for which my client instructs me that there is not a shadow of foundation, but as they have been made by you in a journal which has a certain circulation, and you have thought fit to publish this statement to the world through the medium of your paper, I have now, on behalf of my client, to request that you will insert in your next number a full and detailed retraction and apology (in the same portion of your paper and with the same prominence as that given to the libellous statements in question), and that you will pay for the insertion of such retraction and apology in such paper or papers connected with the boot and shoe trade as may be designated by my client.

Failing hearing from you in the course of the week that you accept these terms without qualification and reserve, and with the draft of the proposed retraction and apology for my perusal and approval on behalf of my client, I am instructed to take immediate steps for the vindication of my client's character, and to obtain exemplary damages for the gross and unwarranted libel committed on him.—I am, Sir, yours obediently,

RALPH RAPHAEL.

59, Moorgate-street, London, E.C.,
May 26th, 1892.

METROPOLITAN ELECTRIC SUPPLY COMPANY'S BALANCE-SHEET.

SIR,—As an investor in electric light companies' shares, I was much interested in the article in your issue of the 6th inst. on the report and accounts of the Metropolitan Electric Supply Company. Before the appearance of your article it had been my intention to take some further shares in this company, but since its appearance I have made it my duty to look closely into the report and accounts, and the opinion at which I have arrived, as the result of this investigation, does not agree with that of some of your contemporaries as to the value of this company's shares; and as there may be other investors similarly placed, I trust you will allow me to set forth my reasons for arriving at this conclusion. They are as follows:

This company commenced operations in 1888. I have before me the report and accounts for the 15 months ending 31st December, 1890, and for the 31st December, 1891. I find from the former of these reports that the number of lamps at the close of 1889 was 14,000, and at the close of 1890, 48,000. The following are also extracts from this company's report: "The company's stations at Whitehall, Sardinia-street, Rathbone-place, and Manchester-square are now completed"; and, "it is confidently anticipated that the new station for the Paddington district, the machinery for which is in a forward state, will be at work in time for next winter's lighting, and "these stations, with the mains and other necessary plant, will about absorb the company's present issue of capital."

I also find, from the accounts accompanying this report, that up to the 30th September, 1889, the sum of £11,408. 9s. 4d.—proportion of directors' fees, salaries, rent, rates and taxes, consulting engineers, law, etc., charges—were placed to capital account, and £13,025. 13s. 10d. as a proportion of similar charges to the 31st December, 1890, was also placed to capital account, making a total of £24,434. 3s. 2d. Although this appears a very large sum with which to load capital, it is possible that, owing to the work of construction and completing all their stations, it is justified; but the fact of their declaring in the same report a dividend of 2s. per share, and intimating that their lamps had risen to 58,000, seem to imply that they had, if not altogether, at any rate very nearly, left the construction and entered into the revenue-producing stage, and that the revenue account in future would show the full expenditure.

On referring to the report and accounts for the year ending year 1891, I find a different state of affairs to what

might be expected from the foregoing. Instead of the Paddington station, "with the mains and other necessary plant, being completed" for "about the company's present issue of capital," I find that additional capital to the extent of £100,000 is required for this purpose, and although the number of lamps at the end of the year had reached 82,000, and consequently the company might now be said to have emerged from the construction stage, capital is again debited with no less than £9,459. 17s. 11d., as a proportion of directors' fees, salaries, etc.—charges which are usually debited to revenue—thus making the total of such charges as transferred £33,894. 1s. 1d. It would be interesting to know what this is worth as an asset. Although the amount transferred to capital account for these charges during 1891 almost equals the gross profits shown in the revenue account, this is only accomplished after this account has been credited with the sum of £3,027. 1s. 3d., being the amount allowed by contractors in lieu of coal, oil, water, etc., during the erection of installations. In my opinion this item certainly requires some further explanation, and one naturally asks if this is the proper account for it to be placed to. On comparing the coal and oil, etc., accounts for the two years, I do not find that those of 1891 are out of proportion with the 1890 accounts. If it is held that the sum covers both years, then "net revenue" account, in my opinion, is the proper account, and not the revenue account for the year.

With an average of, say, 70,000 lights connected for the year, a dividend of 4s. per £10 share, after transferring £9,459. 17s. 11d. of expenses to capital, and crediting that account with an item of £3,027. 1s. 3d., which cannot be expected to occur again, and with the whole of the original capital spent, the result cannot be considered a very satisfactory one, and I cannot agree with a contemporary of yours which states that this company's £10 shares at £7. 10s. are the cheapest in the market.

I am beholden to you for your article, which has enabled me to make these investigations, as it has made me pause before taking any further shares, and I feel sure that other investors considering them will be led to make similar investigations.—Yours, etc., ACTUARY.

May 31, 1892.

ELECTRIC LOCOMOTIVES: A CORRECTION.

SIR,—A passage in the newly-published fourth edition of my "Dynamo-Electric Machinery" requires correction, being technically inaccurate. On page 616 the statement occurs that the electric locomotives of the South London Electric Railway are now being replaced by some of Messrs. Siemens's locomotives. In justice to Messrs. Mather and Platt it ought to be stated that the 14 original locomotives supplied by them are still running, and that they have run in the aggregate no less than 450,000 miles. The two more recent locomotives supplied by Messrs. Siemens do not replace, but are supplementary to, the original engines.—Yours, etc.,

June 1, 1892. SILVANUS P. THOMPSON.

INSTITUTION OF ELECTRICAL ENGINEERS.

The two hundred and fortieth ordinary general meeting of the Institution was held at the Institution of Civil Engineers, 25, Great George-street, Westminster, on Thursday evening, May 26, 1891, Prof. W. E. Ayrton, F.R.S., president, in the chair.

Before proceeding to the business of the meeting, the PRESIDENT had a melancholy duty to perform in announcing the lamentable death of Mr. Willans. It was quite unnecessary, he said, for him to say anything to make the members appreciate this loss to the society. Mr. Willans was a man of great scientific attainments, as well as being a very distinguished engineer. Not only was it a loss to the society, but to the electrical engineering profession, and that at the present time must be regarded as a loss to their country. Nobody knew Mr. Willans better than Mr. Crompton, who was therefore asked to say a few words about the loss sustained.

Mr. R. E. B. CROMPTON had often spoken to the members and always with pleasure; but that time it was with a very different feeling. He had that day returned from the funeral of their friend. He said nothing about his private feelings, as he had lost a man whom he really liked better than any other. He had been very closely connected with him for many years, and never had a quarrel. But speaking from the point of view of the loss which the profession—in fact, he might say Englishmen as a whole—had sustained, he believed it was only in that room where it would be thoroughly realised. There were many in the room who had, like himself, experienced the great assistance of Mr. Willans. Mr. Willans was one of those modest, unassuming men who would stand at your side and give you advice which you found of incalculable value, and he did it in such a way that you thought the suggestion came from yourself more than from him; but now that he had gone a great many would find the difference. He did not think that the outside world knew that in Mr. Willans they had lost probably the greatest steam engineer of the time. That was his opinion, and he believed it was the opinion of a great many others who thought they knew. He was in the prime of life, and had just begun to make his opinions felt. He believed another few years would have made the whole world acknowledge that in Mr. Willans they had a man who had revolutionised the whole of steam engineering. It was very sad that his career should have been cut short in the melancholy manner it had been. It only showed what a little stood between them and eternity. He did not know what he could add to what he had said, further than that he believed nowhere in the world would a more hearty vote of sympathy arise than from the members of the electrical profession, whose labours Mr. Willans had so greatly aided, and nobody would more greatly regret the gap his death had left among them.

The names of new candidates for election into the Institution were announced, and, this being the last meeting of the session, were balloted for.

The PRESIDENT announced that the Council had made their first award of the Salomons scholarship, value £35, to a matriculated second-year student in the Central Institution electrical engineering department—Mr. C. H. C. Woodhouse. He then called on Mr. A. W. Heaviside and Mr. R. C. Jackson to read their paper on "Electrical Distribution by the Newcastle-on-Tyne Electric Supply Company," which we reprint elsewhere.

TRIPLE-POLE MAIN SWITCH.

Messrs. Dorman and Smith have recently "tripled" their B type main switch, and the result is shown in the

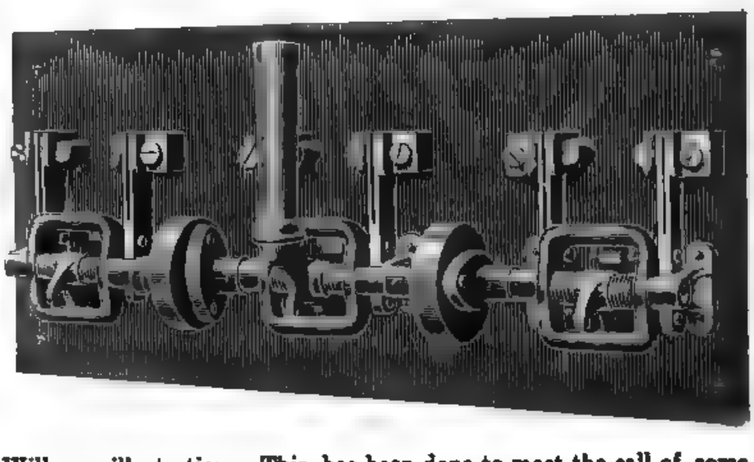


illustration. This has been done to meet the call of some of the supply companies who are desirous of breaking three wires simultaneously. The arrangement, as will be seen, consists of mounting three sudden-release double-break main switches side by side, and working them by means of a single handle on an insulated shaft.

WEAVING BY ELECTRICITY.

The council of the Blackburn Technical School has recently witnessed some exceedingly interesting experiments at the loom works of Mr. Henry Livesey, Greenbank, Blackburn. The experiments were made to test the application of electricity as a motive power for looms, and they proved to be eminently satisfactory. Mr. Livesey is a member of the Technical School Council, and when it was found that the dynamo at the school was capable of generating far more power than was required for merely lighting the building, he suggested that some of the current should be used to drive looms. The assistance of Mr. Thomas Barton, electrical engineer, of Ainsworth-street, Blackburn, was sought for to arrange the methods of driving. Mr. Livesey generously put the power, a loom, and space at the disposal of the council, and after experiments extending over a considerable time the difficulties were conquered, and the loom is now in full working order by the new power. It is interesting to note that the very same loom won Mr. Livesey the medal at the Paris Exhibition. The loom is one used for plain goods, and it has a weaving space of 44in. The whole of Mr. Livesey's works are lit by the electric light, generated by a dynamo in the basement. The mains have been connected to a motor which drives the shaft and runs the looms in the ordinary way. The speed is regulated by a switch, and the motion is so beautifully steady that the loom can be run from an exceedingly slow speed up to 300 "picks" a minute. If it were fixed on a solid floor, even a still higher rate of speed could be obtained. There is sufficient power at the technical school to run 16 or more looms. Experiments will be made to see whether the arrangement can be made an economical one, if applied to a large shed. It certainly would be where electricity is used for lighting, and where power is only required for a comparatively few looms. The experiments are felt to be doubly interesting from the fact that they open up great possibilities for using electricity. Should the Corporation put down electric light as is proposed, and the electric light become popular in the houses and shops of Blackburn, there is nothing to prevent electricity being adapted to many domestic and other purposes.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 520.)

One of the experiments performed may be mentioned here by way of illustration. A small piece of pumice-stone was stuck on a platinum wire, and first melted to it in a gas burner. The wire was next placed between two pieces of charcoal and a burner applied so as to produce an intense heat, sufficient to melt down the pumice-stone into a small glass-like button. The platinum wire had to be taken of sufficient thickness to prevent its melting in the fire. While in the charcoal fire, or when held in a burner to gain a better idea of the degree of heat, the button glowed with great brilliancy. The wire with the button was then mounted in a bulb, and upon exhausting the same to a high degree the current was turned on slowly so as to prevent the cracking of the button. The button was heated to the point of fusion, and when it melted it did not, apparently, glow with the same brilliancy as before; and this would indicate a lower temperature. Leaving out of consideration the observer's possible, and even probable, error, the question is, can a body under these conditions be brought from a solid to a liquid state with evolution of less light? When the potential of a body is rapidly alternated it is certain that the structure is jarred. When the potential is very high, although the vibrations may be few—say, 20,000 per second—the effect upon the structure may be considerable. Suppose, for example, that a ruby is melted into a drop by a steady application of energy. When it forms a drop, it will emit visible and invisible waves, which will be in a definite ratio, and to the eye the drop will appear to be of a certain brilliancy. Next, suppose we diminish to any degree we choose the energy steadily supplied, and, instead, supply energy which rises and falls according to a certain law. Now, when the drop is formed, there will be emitted from it three different kinds of vibrations—the ordinary visible, and two kinds of invisible waves: that is, the ordinary dark waves of all lengths, and, in addition, waves of a well-defined character. The latter would not exist by a steady supply of energy, still they help to jar and loosen the structure. If this really be the case, then the ruby drop will emit relatively less visible and more invisible waves than before. Thus it would seem that when a platinum wire, for instance, is fused by currents alternating with extreme rapidity, it emits at the point of fusion less light and more invisible radiation than it does when melted by a steady current, though the total energy used up in the process of fusion is the same in both cases. Or, to cite another example, a lamp filament is not capable of withstanding as long with currents of extreme frequency as it does with steady currents, assuming that it be worked at the same luminous intensity. This means that for rapidly-alternating currents the filament should be shorter and thicker. The higher the frequency—that is, the greater the departure from the steady flow—the worse it would be for the filament. But if the truth of this remark were demonstrated, it would be erroneous to conclude that such a refractory button as used in these bulbs would be deteriorated quicker by currents of extremely high frequency than by steady or low-frequency currents. From experience I may say that just the opposite holds good: the button withstands the bombardment better with currents of very high frequency. But this is due to the fact that a high-frequency discharge passes through a rarefied gas with much greater freedom than a steady or low-frequency discharge, and this will say that with the former we can work with a lower potential or with a less violent impact. As long, then, as the gas is of no consequence, a steady or low-frequency current is better, but as soon as the action of the gas is desired and important, high frequencies are preferable.

In the course of these experiences great many trials were made with all kinds of carbon buttons. Electrodes made of ordinary carbon buttons were decidedly more durable when the buttons were obtained by the application of enormous pressure. Electrodes prepared by depositing carbon in well-known ways did not show up well; they blackened the globe very quickly. From many experiences I conclude that lamp filaments obtained in this manner can be advantageously used only with low potentials and low-frequency currents. Some kinds of carbon withstand so well that, in order to bring them to the point of fusion, it is necessary to employ very small buttons. In this case the observation is rendered very difficult, on account of the intense light produced. Nevertheless, there can be no doubt that all kinds of carbon are fused under the molecular bombardment, but the liquid state must be one of great instability. Of all the bodies tried, there were two which withstood best—diamond and carborundum. These two showed up about equally, but the latter was preferable, for many reasons. As it is more than likely that this body is not yet generally known, I will venture to call your attention to it. It has been recently produced by Mr. E. G. Acheson, of Monongahela City, Pennsylvania, U.S.A. It is intended to replace ordinary diamond powder for polishing precious stones, etc., and I have been informed that it accomplishes this object quite successfully. I do not know why the name "carborundum" has been given to it, unless there is something in the process of its manufacture which justifies this selection. Through the kindness of the inventor, I obtained a short while ago some samples which I desired to test in regard to their qualities of phosphorescence and capability of withstanding high degrees of heat. Carborundum can be obtained in two forms—in the form of "crystals" and of powder. The former appear to the naked eye dark-coloured, but are very brilliant; the latter is of nearly the same colour as ordinary diamond powder, but very much finer. When viewed under a microscope, the samples of crystals given to me did not appear to have any definite form, but rather resembled pieces of broken-up egg coal of fine quality. The majority were opaque, but there were some which were transparent and coloured. The crystals are a kind of carbon containing some impurities; they are extremely hard, and withstand for a long time even an oxygen blast. When the blast is directed against them, they at first form a cake of some compactness, probably in consequence of the fusion of impurities they contain. The mass withstands for a very long time the blast without further fusion; but a slow carrying off or burning occurs, and finally a small quantity of a glass-like residue is left, which, I suppose, is melted alumina. When compressed strongly they conduct very well, but not as well as ordinary carbon. The powder, which is obtained from the crystals in some way, is practically non-conducting. It affords a magnificent polishing material for stones. The time has been too short to make a satisfactory study of the properties of this product, but enough experience has been gained in the few weeks I have experimented upon it to say that it does possess some remarkable properties in many repects. It withstands excessively high degrees of heat, it is little deteriorated by molecular bombardment, and it does not blacken the globe as ordinary carbon does. The only difficulty which I have found in its use in connection with these experiments was to find some binding material which would resist the heat and the effect of the bombardment as successfully as carborundum itself does. I have here a number of bulbs which I have provided with buttons of carborundum. To make such a button of carborundum crystals I proceed in the following manner: I take an ordinary lamp filament and dip its point in tar, or some other thick substance or paint which may be readily carbonised. I next pass the point of the filament through the crystals, and then hold it vertically over a hot plate. The tar softens and forms a drop on the point of the filament, the crystals adhering to the surface of the drop. By regulating the distance from the plate the tar is slowly dried out and the button becomes solid. I then once more dip the button in tar and hold it again over a plate until the tar

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

is evaporated, leaving only a hard mass which firmly binds the crystals. When a larger button is required, I repeat the process several times, and I generally also cover the filament a certain distance below the button with crystals. The button being mounted in a bulb, when a good vacuum has been reached, first a weak, and then a strong discharge is passed through the bulb to carbonise the tar and expel all gases, and later it is brought to a very intense incandescence. When the powder is used I have found it best to proceed as follows: I make a thick paint of carborundum and tar, and pass a lamp filament through the paint. Taking then most of the paint off by rubbing the filament against a piece of chamois leather, I hold it over a hot plate until the tar evaporates and the coating becomes firm. I repeat this process as many times as it is necessary to obtain a certain thickness of coating. On the point of the coated filament I form a button in the same manner. There is no doubt that such a button—properly prepared under great pressure—of carborundum, especially of powder of the best quality, will withstand the effect of the bombardment fully as good as anything we know. The difficulty is that the binding material gives way, and the carborundum is slowly thrown off after some time. As it does not seem to blacken the globe in the least, it might be found useful for coating the filaments of ordinary incandescent lamps, and I think that it is even possible to produce thin threads or sticks of carborundum which will replace the ordinary filament in an incandescent lamp. A carborundum coating seems to be more durable than other coatings, not only because the carborundum can withstand high degrees of heat, but also because it seems to unite with the carbon better than any other material I have tried. A coating of zirconia or any other oxide, for instance, is far more quickly destroyed. I prepared buttons of diamond dust in the same manner as of carborundum, and these came in durability nearest to those prepared of carborundum, but the binding paste gave way much more quickly in the diamond buttons; this, however, I attributed to the size and irregularity of the grains of the diamond It was of interest to find whether carborundum possesses the quality of phosphorescence. One is, of course, prepared to encounter two difficulties: first, as regards the rough product, the "crystals," they are good conducting, and it is a fact that conductors do not phosphoresce; second, the powder, being exceedingly fine, would not be apt to exhibit very prominently this quality, since we know that when crystals, even such as diamond or ruby, are finely powdered they lose the property of phosphorescence to a considerable degree.

The question presents itself here, Can a conductor phosphoresce? What is there in such a body as a metal, for instance, that would deprive it of the quality of phosphorescence, unless it is that property which characterises it as a conductor? for it is a fact that most of the phosphorescent bodies lose that quality when they are sufficiently heated to become more or less conducting. Then, if a metal be in a large measure, or perhaps entirely, deprived of that property, it should be capable of phosphorescence. Therefore it is quite possible that at some extremely high frequency, when behaving practically as a non-conductor, a metal or any other conductor might exhibit the quality of phosphorescence, even though it be entirely incapable of phosphorescing under the impact of a low-frequency discharge. There is, however, another possible way how a conductor might at least appear to phosphoresce. Considerable doubt still exists as to what really is phosphorescence, and as to whether the various phenomena comprised under this head are due to the same causes. Suppose that in an exhausted bulb, under the molecular impact, the surface of a piece of metal or other conductor is rendered strongly luminous, but at the same time it is found that it remains comparatively cool, would not this luminosity be called phosphorescence? Now such a result, theoretically at least, is possible, for it is a mere question of potential, or speed. Assume the potential of the electrode, and consequently the speed of the projected atoms, to be sufficiently high, the surface of the metal piece against which the atoms are projected would be rendered highly incandescent, since the process of heat generation would be incomparably faster than that of radiating or conducting away from the surface of the collision. In the eye of the observer, a single impact of the atoms would cause an instantaneous flash; but if the impacts were repeated with sufficient rapidity, they would produce a continuous impression upon his retina. To him then the surface of the metal would appear continuously incandescent and of constant luminous intensity, while in reality the light would be either intermittent or at least changing periodically in intensity. The metal piece would rise in temperature until equilibrium was attained—that is, until the energy continuously radiated would equal that intermittently supplied. But the supplied energy might under such conditions not be sufficient to bring the body to any more than a very moderate mean temperature, especially if the frequency of the atomic impacts be very low—just enough that the fluctuation of the intensity of the light emitted could not be detected by the eye. The body would now, owing to the manner in which the energy is supplied, emit a strong light, and yet be a comparatively very low mean temperature. How could the observer call the luminosity thus produced? Even if the analysis of the light would teach him something definite, still he would probably rank it under the phenomena of phosphorescence. It is conceivable that in such a way both conducting and non-conducting bodies may be maintained at a certain luminous intensity, but the energy required would very greatly vary with the nature and properties of the bodies. These and some foregoing remarks of a speculative nature were made merely to bring out curious features of alternate currents or electric impulses. By their help we may cause a body to emit more light, while at a certain mean temperature, than it would emit if brought to that temperature by a steady supply; and, again, we may bring a body to the point of fusion and cause it to emit less light than when fused by the application of energy in ordinary ways. It all depends on how we supply the energy, and what kind of vibrations we set up. In one case the vibrations are more, in the other less, adapted to affect our sense of vision.

Some effects, which I had not observed before, obtained with carborundum in the first trials I attributed to phosphorescence, but in subsequent experiments it appeared that it was devoid of that quality. The crystals possess a noteworthy feature. In a bulb provided with a single electrode in the shape of a small circular metal disc, for instance, at a certain degree of exhaustion the electrode is covered with a milky film, which is separated by a dark space from the glow filling the bulb. When the metal disc is covered with carborundum crystals, the film is far more intense, and snow-white. This I found later to be merely an effect of the bright surface of the crystals, for when an aluminium electrode was highly polished it exhibited more or less the same phenomenon. I made a number of experiments with the samples of crystals obtained, principally because it would have been of special interest to find that they are capable of phosphorescence, on account of their being conducting. I could not produce phosphorescence distinctly, but I must remark that a decisive opinion cannot be formed until other experimenters have gone over the same ground. The powder behaved in some experiments as though it contained alumina, but it did not exhibit with sufficient distinctness the red of the latter. Its dead colour brightens considerably under the molecular impact, but I am now convinced it does not phosphoresce. Still, the tests with the powder are not conclusive, because powdered carborundum probably does not behave like a phosphorescent sulphide, for example, which could be finely powdered without impairing the phosphorescence, but rather like powdered ruby or diamond, and therefore it would be necessary, in order to make a decisive test, to obtain it in a large lump and polish up the surface. If the carborundum proves useful in connection with these and similar experiments, its chief value will be found in the production of coatings, thin conductors, buttons, or other electrodes capable of withstanding extremely high degrees of heat.

The production of a small electrode capable of withstanding enormous temperatures I regard as of the greatest importance in the manufacture of light. It would enable us to obtain, by means of currents of very high frequencies, certainly twenty times, if not more, the quantity of light which is obtained in the present incandescent lamp by the same expenditure of energy. This estimate may appear to many exaggerated, but in reality I think it is far from being so. As this statement might be misunderstood, I think it necessary to expose clearly the problem with which in this line of work we are confronted, and the manner in which, in my opinion, a solution will be arrived at. Anyone who begins a study of the problem will be apt to think that what is wanted in a lamp with an electrode is a very high degree of incandescence of the electrode. There he will be mistaken. The high incandescence of the button is a necessary evil, but what is really wanted is the high incandescence of the gas surrounding the button. In other words, the problem in such a lamp is to bring a mass of gas to the highest possible incandescence. The higher the incandescence, the quicker the mean vibration, the greater is the economy of the light production. But to maintain a mass of gas at a high degree of incandescence in a glass vessel, it will always be necessary to keep the incandescent mass away from the glass—that is, to confine it as much as possible to the central portion of the globe. In one of the experiments this evening a brush was produced at the end of a wire. This brush was a flame, a source of heat and light. It did not emit much perceptible heat, nor did it glow with an intense light; but is it the less a flame because it does not scorch my hand? Is it the less a flame because it does not hurt my eye by its brilliancy? The problem is precisely to produce in the bulb such a flame, much smaller in size, but incomparably more powerful. Were there means at hand producing electric impulses of a sufficiently high frequency, and for transmitting them, the bulb could be done away with, unless it were used to protect the electrode, or to economise the energy by confining the heat. But as such means are not at disposal, it becomes necessary to place the terminal in a bulb and rarefy the air in the same. This is done merely to enable the apparatus to perform the work which it is not capable of performing at ordinary air pressure. In the bulb we are able to intensify the action to any degree—so far that the brush emits a powerful light. The intensity of the light emitted depends principally on the frequency and potential of the impulses, and on the electric density of the surface of the electrode. It is of the greatest importance to employ the smallest possible button, in order to push the density very far. Under the violent impact of the molecules of the gas surrounding it, the small electrode is of course brought to an extremely high temperature, but around it is a mass of highly incandescent gas, a flame or photosphere, many hundred times the volume of the electrode. With a diamond, carborundum, or zirconia button the photosphere can be as much as one thousand times the volume of the button. Without much reflecting one would think that in pushing so far the incandescence of the electrode it would be instantly volatilised. But after a careful consideration he would find that, theoretically, it should not occur, and in this fact—which, however, is experimentally demonstrated—lies principally the future value of such a lamp. At first, when the bombardment begins, most of the work is performed on the surface of the button, but when a highly-conducting photosphere is formed the button is comparatively relieved. The higher the incandescence of the photosphere the more it approaches in conductivity to that of the electrode, and

the more, therefore, the solid and the gas form one conducting body. The consequence is that, the further is forced the incandescence the more work, comparatively, is performed on the gas, and the less on the electrode. The formation of a powerful photosphere is consequently the very means for protecting the electrode. This protection, of course, is a relative one, and it should not be thought that by pushing the incandescence higher the electrode is actually less deteriorated. Still, theoretically, with extreme frequencies, this result must be reached, but probably at a temperature too high for most of the refractory bodies known. Given, then, an electrode which can withstand to a certain very high limit the effect of the bombardment and outward strain, it would be safe no matter how much it is forced beyond that limit. In an incandescent lamp quite different considerations apply. There the gas is not at all concerned; the whole of the work is performed on the filament, and the life of the lamp diminishes so rapidly with the increase of the degree of incandescence, that economical reasons compel us to work it at a low incandescence. But if an incandescent lamp is operated with currents of very high frequency, the action of the gas cannot be neglected, and the rules for the most economical working must be considerably modified.

In order to bring such a lamp with one or two electrodes to great perfection, it is necessary to employ impulses of very high frequency. The high frequency secures, among others, two chief advantages, which have a most important bearing upon the economy of the light production. Firstly, the deterioration of the electrode is reduced by reason of the fact that we employ a great many small impacts, instead of few violent ones, which shatter quickly the structure; secondly, the formation of a large photosphere is facilitated. In order to reduce the deterioration of the electrode to the minimum, it is desirable that the vibration be harmonic, for any suddenness hastens the process of destruction. An electrode lasts much longer when kept at incandescence by currents, or impulses, obtained from a high-frequency alternator, which rise and fall more or less harmonically, than by impulses obtained from a disruptive discharge coil. In the latter case there is no doubt that most of the damage is done by the fundamental sudden discharges. One of the elements of loss in such a lamp is the bombardment of the globe. As the potential is very high, the molecules are projected with great speed; they strike the glass, and usually excite a strong phosphorescence. The effect produced is very pretty, but for economical reasons it would be perhaps preferable to prevent, or at least reduce to the minimum, the bombardment against the globe, as in such case it is, as a rule, not the object to excite phosphorescence, and as some loss of energy results from the bombardment. This loss in the bulb is principally dependent on the potential of the impulses, and on the electric density on the surface of the electrode. In employing very high frequencies the loss of energy by the bombardment is greatly reduced, for, firstly, the potential needed to perform a given amount of work is much smaller, and, secondly, by producing a highly-conducting photosphere around the electrode, the same result is obtained as though the electrode were much larger, which is equivalent to a smaller electric density. But be it by the diminution of the maximum potential or of the density, the gain is effected in the same manner—namely, by avoiding violent shocks, which strain the glass much beyond its limit of elasticity. If the frequency could be brought high enough, the loss due to the imperfect elasticity of the glass would be entirely negligible. The loss due to bombardment of the globe may, however, be reduced by using two electrodes instead of one. In such case each of the electrodes may be connected to one of the terminals; or else, if it is preferable to use only one wire, one electrode may be connected to one terminal, and the other to the ground or to an insulated body of some surface, as, for instance, a shade on the lamp. In the latter case, unless some judgment is used, one of the electrodes might glow more intensely than the other. But, on the whole, I find it preferable when using such high frequencies to employ only one electrode and one connecting wire. I am convinced that the illuminating device of the near future will not require for its operation more than one lead, and, at any rate, it will have no leading-in wire, since the energy required can be as well transmitted through the glass. In experimental bulbs the leading-in wire is most generally used on account of convenience, as in employing condenser coatings in the manner indicated in Fig. 22, for example, there is some difficulty in fitting the parts, but these difficulties would not exist if a great many bulbs were manufactured; otherwise the energy can be conveyed through the glass as well as through a wire, and with these high frequencies the losses are very small. Such illuminating devices will necessarily involve the use of very high potentials, and this, in the eyes of practical men, might be an objectionable feature. Yet, in reality, high potentials are not objectionable—certainly not in the least as far as the safety of the devices is concerned.

There are two ways of rendering an electric appliance safe. One is to use low potentials, the other is to determine the dimensions of the apparatus so that it is safe no matter how high a potential is used. Of the two, the latter seems to me the better way, for then the safety is absolute, unaffected by any possible combination of circumstances which might render even a low-potential appliance dangerous to life and property. But the practical conditions require not only the judicious determination of the dimensions of the apparatus; they likewise necessitate the employment of energy of the proper kind. It is easy, for instance, to construct a transformer capable of giving, when operated from an ordinary alternate-current machine of low tension—say, 50,000 volts—which might be required to light a highly-exhausted phosphorescent tube, so that, in spite of the high potential, it is perfectly safe, the shock from it producing no inconvenience. Still, such a transformer would be expensive, and in itself inefficient; and, besides, what energy was obtained from it would not be economically used for the production of light. The economy demands the employment of energy in the form of extremely rapid vibrations. The problem of producing light has been likened to that of maintaining a certain high-pitched note by means of a bell. It should be said a barely audible note; and even these words would not express it, so wonderful is the sensitiveness of the eye. We may deliver powerful blows at long intervals, waste a good deal of energy, and still not get what we want; or we may keep up the note by delivering frequent gentle taps, and get nearer to the object sought by the expenditure of much less energy. In the production of light, so far as the illuminating device is concerned, there can be only one rule—that is, to use as high frequencies as can be obtained; but the means for the production and conveyance of impulses of such character impose, at present at least, great limitations. Once it is decided to use very high frequencies, the return wire becomes unnecessary, and all the appliances are simplified. By the use of obvious means the same result is obtained as though the return wire were used. It is sufficient for this purpose to bring in contact with the bulb, or merely in the vicinity of the same, an insulated body of some surface. This surface need, of course, be the smaller the higher the frequency and potential used, and necessarily, also, the higher the economy of the lamp or other device. This plan of working has been resorted to on several occasions this evening. So, for instance, when the incandescence of a button was produced by grasping the bulb with the hand, the body of the experimenter merely served to intensify the action. The bulb used was similar to that illustrated in Fig. 19, and the coil was excited to a small potential, not sufficient to bring the button to incandescence when the bulb was hanging from the wire; and incidentally, in order to perform the experiment in a more suitable manner, the button was taken so large that a perceptible time had to elapse before, upon grasping the bulb, it could be rendered incandescent. The contact with the bulb was, of course, quite unnecessary. It is easy, by using a rather large bulb with an exceedingly small electrode, to adjust the conditions so that the latter is brought to bright incandescence by the mere approach of the experimenter within a few feet of the bulb, and that the incandescence subsides upon his receding.

In another experiment, when phosphorescence was excited, a similar bulb was used. Here again, originally, the potential was not sufficient to excite phosphorescence until the action was intensified—in this case, however, to present a different feature, by touching the socket with a metallic object held in the hand. The electrode in the bulb was a carbon button so large that it could not be brought to incandescence and thereby spoil the effect produced by phosphorescence. Again, in another of the early experiments, a bulb was used as illustrated in Fig. 12. In this instance, by touching the bulb with one or two fingers, one or two shadows of the stem inside were projected against the glass, the touch of the finger producing the same result as the application of an external negative electrode under ordinary circumstances.

(To be continued.)

PHYSICAL SOCIETY.—May 13, 1892.

Dr. E. Atkinson, treasurer, in the chair.

Mr. Gerrans was elected a member of the society.

After a paper by **Mr. R. Inwards** on "**An Instrument for Drawing Parabolas**,"

Mr. F. H. Nalder exhibited and described "**Some Electrical Instruments.**" The first shown was a ballistic galvanometer with one pair of coils, the distinguishing features of which were accessibility, small damping, great sensitiveness, and the arrangement of the control. The control is effected by a tail magnet carried on a horizontal tube, supported by a pillar outside the case, as suggested by Prof. R. M. Walmsley. A small magnet on the cover serves for zero adjustment. The suspended system consists of four bell magnets, two being in the middle of the coil and one at top and bottom respectively, arranged so as to be astatic. The sensitiveness of the instrument shown was such that a quarter of a microcoulomb gave 300 divisions (fortieths of an inch), when the periodic time was 10 seconds and scale distance about 3ft.; resistance of galvanometer about 10,000 ohms. To bring the needle to rest quickly, a damping coil mounted on an adjustable stand and a special reversing key with resistances in its base are provided. The key has successive contacts arranged so that when pressed lightly only a weak current passes round the damping coil, whilst when pressed further a much stronger current passes. The strong currents are used to check the large elongations, and the weak ones for finally bringing to zero. A lampstand with semi-transparent scale arranged for use with a glow lamp was next shown. Instead of reading by the image of the filament, as is ordinarily done, the lantern is arranged to give a bright disc of light with a black line across the middle. **Mr. Blakesley** asked if the galvanometer was astatic. For damping non-astatic ones he had found it useful to wind several turns of wire round the bobbin, and put them in series with a few thermo-electric junctions warmed by the hand and a key. In reply, **Mr. Nalder** said the galvanometer was astatic, but the damping coil could be placed so as to act on one pair of magnets more than on the other.

A paper on "**A Portable Instrument for Measuring Magnetic Fields, with Some Observations on the Strength of the Stray**

Fields of Dynamos," by **Mr. E. Edgar** and **Mr. H. Stansfield**, was then read. The instrument was described as an inversion of a d'Arsonval galvanometer, for the torque necessary to maintain a suspended coil conveying a constant current parallel to the field gives a measure of the strength of the field. The constant current is furnished by a Hellesen's dry cell, which the authors found remarkably constant. The instrument consists of a coil of about 50 ohms wound on mica, and suspended by two German silver strips within a tube. A pointer is fixed to the mica, and a divided head, to which the outer end of one strip is attached, serves to measure the torsion. Within the head chamber is a commutator which automatically reverse the current in the coil when the head is turned in opposite directions from zero. Two readings may thus be taken to eliminate gravity errors due to want of perfect balance in the coil. Means are provided for adjusting and measuring the tension of the suspensions. The constant of the instrument was determined by placing the coil in the field of a Helmholtz galvanometer, and found to be 0·293 per 1deg. Any other field is therefore given by $0·293\,(n+1)\,\theta$, where θ is the angle of torsion in degrees, and n the multiple of 50 ohms in series with the coil. Fields from two or three C.G.S. lines upwards can be measured to about 2 per cent. by the instrument, and even the earth's field is appreciable. The authors have tested the fields of dynamos at the Crystal Palace Exhibition and elsewhere, and the results obtained are given in the paper. It is noted that the stray field of multipolar machines fall off much more rapidly than those of two-pole dynamos as the distances are increased, and that near edges and corners of the magnets the fields are much stronger than near flat surfaces. The disturbing effect of armature reactions on the strength of the stray field were measured and shapes of the field observed in some cases. Experiments on magnetised watches are described in the paper. **Mr. Whipple** said the Kew Committee were to some extent responsible for the experiments described, for it was on their account that the investigations were commenced. In connection with the rating of so-called non-magnetic watches, it was necessary to know what strength of fields they were likely to be subjected to. The instrument devised for making the tests was a very interesting one, and the results obtained by it of great value. **Mr. A. P. Trotter** hoped the authors would supplement their work by tracing out the directions of the fields of dynamos, and he described a simple method of doing this by a test needle used as an indiarubber stamp. The question of watches, he thought, must be considered soon; even non-magnetic watches were stopped by being placed in strong fields, owing to Foucault currents generated in the moving parts. **Mr. Blakesley** enquired whether the instrument could be used in any position. He thought three observations would be necessary to completely determine any field. **Mr. Stansfield**, in reply, said they used a pilot needle for showing the direction of the fields, and then placed the coil accordingly. The instrument could be used in any position, for the weight of the coil was only about two grammes, and did not greatly alter the tension of the suspensions, which was usually about 300 grammes. A watch with a brass balance was not influenced by a field of 10 C.G.S. lines, but seriously affected by one of 40.

THE TELEPHONE SYSTEM.

The following Treasury Minute, dated May 23, 1892, upon the proposals for the development of the telephone system in the United Kingdom has been issued as a parliamentary paper:

My Lords have before them the proposals of the Postmaster-General for carrying out the policy which has been adopted by her Majesty's Government for development of the telephone system in the United Kingdom.

1. It is the object of these proposals, while preserving the property in the telegraphs, which has been paid for by the nation, to secure that expansion of the telephone system which is called for by public opinion and the necessities of commerce. It is impossible to continue the present system under which the telegraph revenue is seriously suffering, while, on the other hand, the extension of telephones is checked in a manner which cannot be permanently maintained. The proposals of the Postmaster-General will enable the telephone companies and the Post Office to co-operate in services to the public.

2. The telephone companies are at present restricted to oral communications. The scheme prepared by the Postmaster-General will in one direction, as hereafter explained, remove that restriction; and it proposes the establishment of trunk wires throughout the United Kingdom.

3. Unless trunk wires are in the hands of the State, a monopoly, injurious to the public interest, would inevitably ensue, to the advantage of the company which first laid down such trunk wires.

4. If, on the removal of the restriction to oral communications, the companies were allowed themselves to write down and deliver messages and a network of trunk wires were spread over the country, by private enterprise, the distinction, established by Mr. Fawcett, between the business of the companies and of the Post Office would disappear, and rival systems of telegraphy would be working side by side where Parliament intended that there should be only one.

5. For this reason it is proposed that the Post Office shall write down and deliver the messages, and that the Post Office shall provide a national system of trunk lines. United action on the part of the companies and the Post Office is necessary to the success of the scheme.

6. It is proposed that the companies should abandon their right to construct trunk wires, and that the Post Office should purchase from them such as they have already erected; and that in addition to this the Post Office should gradually provide additional trunk wires, so that there may ultimately be a complete system of communication between all the important towns in the kingdom. It is further proposed that a connecting link between Great Britain and Ireland should be furnished by a submarine cable, and that the whole system should be open, not only to the subscribers of the companies, but also to any member of the public who may choose to come to a post office for the purpose of using it.

7. The companies will connect their exchanges with the offices of the Post Office, in order that their subscribers may telephone messages—(*a*) for transmission over the public telegraphs; (*b*) for transmission through the post as letters; (*c*) for delivery as express letters; (*d*) that they may call for the service of express messengers; and may (*e*) request to be placed in telephonic communication with other towns by means of the trunk wires of the State.

8. The Post Office will make no charge for the services of its officers who attend to the wires connecting the exchanges with the local post offices, and will pay the companies a commission of 5 per cent on ordinary telegrams telephoned to those offices for transmission by the public telegraphs.

9. The Post Office will withdraw its veto on the establishment by the companies of public call offices in the houses and shops of sub-postmasters. It will, further, be a consideration whether, if the convenience of the department will permit it, head, district, and branch post offices should be allowed to be used as call offices, etc., subject to such payment by way of rent as may be agreed on.

10. As far as practicable, the Post Office will provide underground wires at an agreed rent to connect together the exchanges of a company within one and the same exchange area, so that the municipal authorities may not have to complain of their streets being disturbed by the companies, which, in some places, might be in competition.

11. The Post Office, where it can permit telephone companies to use railways, canals, or other property over which it has acquired exclusive rights of way for telegraphs, will charge a nominal sum of 1s. per mile of wire instead of 20s as at present.

12. Parliament, by a Bill now about to be introduced, will be asked to confer on the companies, subject to the consent of the local authority, powers for the erection of the wires required to connect their exchanges with the houses of their subscribers.

13. The messages telephoned to post offices for delivery will have to be limited in length, and it is proposed to adopt the two-fold limit of three minutes and 30 words. The charge will be the same as for an ordinary express letter—viz., 3d.—if the address be within a mile of the post office where the message is written down.*

14. For conversations on the trunk wires of the State the following charges will, it is thought, be equitable, while, at the same time, sufficient to secure a margin of profit*: For any distance not exceeding 20 miles, 3d.; for any distance exceeding 20 miles and not exceeding 40 miles, 6d.; for every additional 40 miles or fraction thereof, 6d.

15. A charge of 6d. for 40 miles has been sanctioned by the Treasury for the trunk wires already provided by the Post Office, but the charge of 3d. for 20 miles is new. The Post Office consider it necessary that there should be this lower charge for the short wires. Longer distances cannot be charged for at a less rate, as, although it is true that the terminal expenses are a fixed quantity, the expenses of construction and maintenance will, even in proportion, increase greatly with the length of the line. Where a submarine cable is used, or where exceptional expense is incurred, an additional charge will be made.

16. As in the case of the London-Paris Telephone line, the period of each conversation will be three minutes, and two consecutive periods will be allowed for a double payment.

17. My Lords will examine with care such schemes as may be successively submitted by the Post Office for the gradual construction of new trunk lines. In the course of a few months wires can be erected on existing poles from London to certain principal places, and progress can be made as convenience permits with further wires in many directions. These works would be carried out in such a manner as to supplement and extend the system acquired from the companies.

18. It must be clearly understood that the right of the Post Office to establish telephone exchanges, which was reserved by Mr. Fawcett, will be maintained, the department holding itself ready, as in the past, to comply with the reasonable demand of any town or district for telephonic facilities.

19. As to fresh licenses, no further license for the whole country will be granted; and even for a license to establish an exchange in a particular town no application will be entertained unless a formal resolution in its favour has been passed by the corporation or other municipal authority, and evidence given that there is sufficient capital subscribed to carry out the undertaking. In this way competition will not be excluded, but a check will be imposed on the formation of companies whose sole object it is to force the existing licensees to buy them up. But although this is the policy which commends itself to her Majesty's Government, it must be distinctly understood that, should licenses hereafter be granted on other principles, no company now or hereafter to be licensed will have any ground to complain of

* These charges are independent of the charges which the companies make on their own account for sending a telephone message.

breach of contract or want of good faith on the part of the Postmaster-General. It will be a condition of any license to a new company that their system must be constructed entirely of twin wires or metallic circuits, so that there may be an assurance of its efficiency.

20. The royalties now payable by the companies to the State will remain unchanged. The other conditions imposed by their licenses will remain unchanged, except so far as they may be modified by the policy indicated in this minute.

21. In conclusion, it may be stated that the intention is to meet, as far as possible, the views of municipal authorities, to aid the telephone companies in the improvement of their exchange system, to place additional facilities at the disposal of the public, and to establish trunk wires between the more important towns throughout the country. My Lords concur.

Let a copy of this minute be laid before Parliament.

ELECTRIC AND CABLE RAILWAYS.

The following extracts show the part taken by the London County Council in connection with the proposed electric railways, and the Joint Committee of the Lords and Commons, whose report we gave in our last issue:

Electric and Cable Railways.

In accordance with the resolutions of the Council we submitted the views of the Council on this matter to the Joint Committee of both Houses of Parliament, and supported the same by the evidence of the agent, the engineer, the chairman of this committee, and the chairman of the Housing Committee. The chairman of the Parliamentary Committee of the London County Council was requested by the Joint Committee to submit a memorandum, and the following memorandum was accordingly submitted to the Joint Committee of Lords and Commons:

It may be desirable to explain that, in suggesting certain amendments to safeguard the public interest, the Council has no wish to take up a position hostile to the promoters of the Bills now under consideration by the committee. The Council is, on the contrary, impressed with the great importance of providing London with additional means of internal communication, and its only desire is that all the various schemes should, in the interest of London's future growth, be dealt with upon broad general principles, so as to make the lines as useful as possible to the public, not only of this but also of future generations. It must be borne in mind that once any of these lines is constructed, it will be for many years practically impossible to construct any other along the same route; nor can the tunnels, once made, be afterwards enlarged, except at an enormous cost. It is therefore inevitable that the proposals of the promoters should be closely scrutinised, as involving the deprivation of the people along that route of the possibility of an alternative service.

The questions now to be decided will go far to establish the principles which will be followed in all future cases, and affect not the present proposals alone, but all future electric lines.

Uniformity of Tunnelling.—The first point urged by the Council is that the size of the tunnels should be uniform for all the London lines. It will be unnecessary to dwell upon the desirability of insisting that the lines should be so constructed as to permit of interchange of traffic with each other. Without uniformity of tunnel, uniformity of gauge may easily become of no use. It is impossible at present to foresee exactly what form of rolling-stock may be found most convenient for this new class of railway, and no one line ought to be allowed to adopt a dimension of tunnel which may be found hereafter to hamper the full development of London's internal communication as seriously as the old "battle of the gauges" hampered English railway development. At present the bills before the committee propose three different dimensions of tunnel—viz., 11ft. 6in., 12ft., and 16ft. It is submitted that a uniform tunnel dimension should be determined on by the committee.

Connection with Existing Railways.—If the committee decide upon a uniform tunnel dimension, the Council urges the importance of so constructing the lines as to leave open the possibility at some future time of interchange of traffic with the existing railways serving the suburban belt. The value of this interchange is recognised by one of the Bills before the committee—viz., the Great Northern and City Railway, which includes proposals for connection with the Great Northern Railway Company near Finsbury Park, and of which the tunnel is accordingly to be 16ft. in diameter.

In connection with its work relating to the housing of the poor, the Council is impressed with the absolute necessity for facilitating a greater spreading of the population. It is of vital importance to the future well-being of London that every possible opportunity should be taken to promote cheap and rapid communication between every part of inner London and what is at present the outer suburban belt. The Council would regard it as a serious calamity to London if the proposed lines were so constructed as absolutely to preclude their forming easy connections with the suburban lines of railway at some future time.

In support of this contention the experience of the Metropolitan and Metropolitan District Railways may be alluded to. Intended originally only as "circle" lines, they have both found it expedient to stretch out into the suburban belt, in order to accommodate the traffic caused by London's constant expansion.

It may very possibly be found equally necessary for the full success of the electric railways that they should possess direct communication with the outer suburbs, rising gradually to the level of the surface railways at a distance of some miles from central London, as the Great Northern and City Railway already proposes to do near Finsbury Park. The possibility of mutual running powers ought not therefore to be precluded.

It has been urged that this object is secured so far as it is practicable by the uniformity of gauge, which would permit the light carriages of the electric lines to run on the present railways, although the rolling-stock of the latter would not be able to enter the deep and narrow tunnels. But it is felt that such an arrangement might easily prove illusory. It must be doubtful whether trains of the peculiar pattern contemplated by the promoters (other than those of the Great Northern and City Railway) could in practice safely be run amid the crush of morning and evening traffic on the existing lines.

It has been urged that ordinary steam locomotives could not be worked at the great depth proposed. But even if this must always be the case, the possibility of electric locomotives being used on the existing railway lines may at any rate not be absolutely excluded from consideration. The form and size of the rolling-stock contemplated by the promoters can scarcely be regarded as other than experimental. No one would assert that the style of omnibus carriage at present in use is entirely satisfactory. The promoters might fairly be required, in the interests of the public, to leave open the possibility of adopting the dimensions actually suggested by one of them—viz., the Great Northern and City Railway. Already in the short history of electric railways has there been a marked tendency to increase the dimensions of the tunnel. The tunnel first proposed for the City and South London Railway was only 9ft. 6in. This was altered to 10ft. The Central London Railway Act of 1891 contemplated a tunnel of 11ft. 6in., which is the size now desired by the City and South London Railway Company for their Islington extension. The Baker-street and Waterloo Railway Bill seeks power for a 12ft. tunnel, which is also the dimension desired for the Waterloo and City Railway. Finally, the Great Northern and City Railway Bill proposes, as has been already mentioned, a tunnel of 16ft.

In this experimental stage of the invention, and with the actual tendency to expansion already indicated, to make the standard tunnel dimension 11ft. 6in. or 12ft. only, would seriously hamper the possibilities of improvement. A 16ft. tunnel would not prevent the use of 11ft. rolling-stock, should this hereafter be found the most convenient size. But a 12ft. tunnel might absolutely prevent the adoption of a whole host of what were found to be desirable improvements.

The committee is therefore asked to adopt the proposal of the Great Northern and City Railway Bill—viz., 16ft.—as the standard tunnel dimension for all electric railways within the London area.

Construction from Point to Point.—The next question which the Council ask the committee to determine is the general direction of the lines. It is for the interest of the public that the shortest and most direct routes should be followed in all cases. Surface railways, and those constructed on the "cut and cover" principle, are necessarily forced to depart from these routes, in order to avoid valuable property. But at the great depth proposed, this consideration becomes less material, as all that need be granted is what is virtually an "easement of tunnelling," with an obligation to pay for actual damage only. But in order to avoid even this compensation (or still more, the legal questions that might be raised if no explicit declaration is inserted in the Bills), the promoters propose to turn and twist their lines so as to follow the direction of main streets. And as the public authority has, in most instances, no actual freehold in the streets, it is contemplated that no claim can be made by it upon the promoters.

It is, however, submitted that considerations of this kind should not be allowed to interfere with the best possible planning of the lines in the public interest. It is highly objectionable that the assumed lack of power in the public authority to claim the same compensation for damages as a private freeholder should further militate against the public interests by encouraging an unnecessarily lengthy and tortuous construction of the lines.

It has been admitted by the engineer to the promoters that if the lines could pass under houses without any greater cost than under streets, it would be desirable, in order to avoid unnecessary curves, to do so.

The Council accordingly suggests that the lines should, wherever physically possible, be made direct from point to point, and that an "easement or right of tunnelling" should be established, carrying with it the obligation to pay only for actual damage, and that, in this respect, the public authority should be placed, as regards the streets, upon the footing of a private freeholder where no other freeholder can show title.

Power to Purchase.—A further principle which the Council urges the committee to adopt is the grant of power to it, as the local authority, to purchase the lines in a manner similar to that laid down for tramways and electric lighting works. It may be observed that it is not proposed that the lines should in any sense "revert" to the local authority without payment (as is the case with foreign concessions), but merely that the local authority should have compulsory power to purchase on fair terms, after the expiration of a reasonable period. A compulsory power to purchase is given, in the case of all English railways, by the Act of 1844, to the National Government. But it is urged that as the lines now proposed are in many respects more akin to tramway than to railway lines, the more recent precedents of the Tramways Act should be followed, due modification being made for the greater cost of the works.

In the absence of any new principle, it will perhaps be assumed that the Act of 1844 would apply to the proposed electric railways.

But if only to avoid such litigation as that which ensued upon the desire of the Postmaster-General to apply to the telephones the provisions of the Telegraph Act, it is desirable that it should be clearly laid down whether the proposed electric railways are to be deemed to be included in the Act of 1844.

To the compulsory power of purchase which would in that case be given to the National Government, the Council desires to offer no objection. But whether or not these electric lines are, for that purpose, to be treated as railways, the Council would strongly urge that their close analogy to tramways should also be considered. They are essentially local in their character, and the Council would suggest that, whatever power to purchase is given to the National Government (which is in the highest degree unlikely ever to exercise it), power of purchase should also be given to the local authority upon the principle adopted in the cases of tramways and electric lighting works.

In support of this contention, the Council would urge that the electric railways are avowedly intended merely as a substitute for tramway locomotion, and that the promoters resist any obligation to undertake the additional services—such as goods traffic, conveyance of cattle, minerals, etc.—performed by ordinary railways.

The position of the local authority with regard to them is very analogous to its position with regard to tramway companies. In the latter case the promoters seek power to use the surface of streets, in which the local authority has usually no fee-simple, but only easements of various kinds. In the case now under consideration the promoters seek power to occupy not the surface, but the subsoil, in which the local authority equally has extensive easements, and of which it, in certain cases, possesses the freehold.

It is submitted that a valuable privilege is sought by the promoters; that it is not proposed by them to make any payment to any public authority in respect of that privilege; that the effect of granting it must necessarily be the creation of a virtual monopoly which cannot fail seriously to affect the public interest; and that it is extremely undesirable to establish such a monopoly without giving some authority representing the public the legal power to review its conditions, after the lapse of a reasonable time, in order that any future injury to the public may be prevented.

The Council is prepared to admit the view that the great cost of the works proposed, and their necessarily experimental character, warrant the grant of a longer period of enjoyment of the monopoly than in the case of the tramways. The period of 21 years, adopted also for electric lighting works, was afterwards enlarged in the case of the latter to 42 years. For electric railways the Council has suggested that the period might reasonably be fixed at 60 years, a term beyond the expectation of life of any investor.

LONDON CHAMBER OF COMMERCE—ELECTRICAL TRADE SECTION.

ANNUAL MEETING.

The annual meeting of the Electrical Trade Section of the London Chamber of Commerce was held at the offices of the Chamber on Friday last. Amongst those present were Mr. R. E. Crompton (the chairman of the section), Major Flood Page, Messrs E. Garcke, Alex. Siemens, W. T. Gaine (National Telephone Company), Colonel Jackson, R. S. Erskine, A. R. Bennett, James Taylor, R. J. Jenkins, C. L. Davies, Geo. B. Woodruff, Henry Edmunds (W. T. Glover and Co.), W. R. Caldwell Moore, F. Faithfull Begg, Musgrave Heaphy, Alfred Thompson, W. W. Beaumont, W. G. Bond, G. Binswanger, Llewelyn B. Atkinson (W. T. Goolden and Co.), S. Morse, Alex. MacGregor, and Robert Hammond.

The **Chairman**, in opening the proceedings, stated that it was his duty to inform them that his period of office had now expired, and he would wish to refer briefly to the work which they had gone into during the past two years, and to foreshadow the work which still lay before them. Speaking generally, he thought he might say that they had reason to congratulate themselves on the success which had attended the formation of the section. He thought it had to a certain extent promoted what was intended—viz., intercourse between the members of the profession. They had met frequently to discuss matters of mutual interest, and that had been the means of causing those who looked upon each other as trade rivals to meet on more of a friendly footing, and had had the effect of combining them into one for the promotion of objects of common interest. He did not propose to take up their time by enumerating anything like all the different topics that had been dealt with by the section. Fortunately, in one way, they had all been so busy that they had not had time to attend meetings as they might have done, and questions that might at a less busy time have been discussed had not been touched. Unfortunately, from one point of view, the section had lately been in antagonism with the Board of Trade on the question of overhead wires. It arose out of a decision of the Board of Trade not to permit the use of overhead wires under any circumstances, a decision which appeared to be manifestly unjust, seeing that they had laid down a code of regulations on the subject on the strength of which a great deal of capital had been expended. He was not one of those who upheld the use of overhead wires in crowded cities, but in rural districts, where electrical energy had to be carried over long distances, it was one of the methods which seemed to lend itself most easily to distribution at a moderate cost, and he thought that the decision of the Board of Trade was one that was to be combated with all their strength. As a consequence of the decision some months ago they had practically canvassed the whole profession through the instrumentality of the Chamber of Commerce, and had been enabled to present so powerful a petition to the Board of Trade that they had at once practically reconsidered their decision. He would not criticise the way in which they had reconsidered their decision. He thought it was better to "let sleeping dogs lie," but he was of opinion that the trade in future would not be treated in such a brusque manner. One or two important matters had been begun by them, but had not been carried forward, principally, he supposed, on account of the happy state of the trade, which left them little time for the consideration of abstract business. He alluded to the standardising of machinery in order to make it as interchangeable as possible. The only practical part carried out was the standardising of the screws used in their machinery. He thought that 99 per cent. of the electrical manufacturers were now using the form of screw which had been proposed by the Small Screw Committee of the British Association. It was universal in England and was interchangeable with the Swiss screw, and was, therefore, practically international. By the agency of the section they had also been able to arrange a visit to the Frankfort Exhibition last year in a body, under conditions which would not have been possible as individuals. They had also been able to do some useful work in connection with another exhibition, that at the Crystal Palace. They had secured its postponement after a conference with the directors of the Crystal Palace. If it had taken place when it was originally proposed, the display, he thought he might venture to say, would not have been half so good as it was. The display had only reached its height in the middle of February, and that was some months later than the date at first determined on by the Crystal Palace authorities. The result, he thought, showed that the exhibition was all the better for postponement. One of the burning questions before them was the question of the telephones and the telephone service in London and in all England. It was a question as to how far the interests of the telephone companies and those of the heavier electrical industries could be brought together so as not to clash. In some respects it appeared as if these interests did clash, and it would be a great pity if vast sums of money had to be expended on law if these questions could be settled by friendly meetings between the representatives of the different interests. He had to intimate his retirement from the chairmanship of the section—a post which he had filled for a longer time than he had intended. He regretted leaving the chair, and he only hoped that his successors would find it as pleasant a duty to serve them in the future as he had found it in the past.

Colonel Raynsford Jackson said that no one could have failed to observe the energy and the knowledge which Mr. Crompton had brought to bear on the various subjects that had come before the section during the time he had presided over them. Feeling that Mr. Crompton was the right man in the right place, he had much pleasure in proposing his re-election.

Mr. R. J. Jenkins, in seconding this, said that they were only giving expression to a feeling of more than satisfaction at the able way in which Mr. Crompton had filled the post.

Mr. Crompton said he appreciated their great kindness and the honour which they meant to do him, but it was impossible for him to continue. There were many reasons why it was desirable that they should have a change. He was rather overworked already, and it was a feeling of great annoyance to him that he had not been able to give the work of the section the time and attention it deserved. To continue, he felt would not be to do justice to his own business and the work of the section. He had considered the matter carefully, and his decision was irrevocable. There was an excellent gentleman to be nominated whom he thought would be acceptable to them all.

Mr. Garcke said that, as vice-chairman, it might be convenient that he should add a few words to what had been said by Colonel Jackson. They had used great efforts to get Mr. Crompton to withdraw his resignation, but without success. He was only echoing the sentiments of all when he said that they received Mr. Crompton's resignation with deep and sincere regret. At the same time, it had to be recollected that Mr. Crompton had served them for four years. It was only right, therefore, that the chairman and the two vice-chairmen (Major Flood Page and himself) should on that occasion tender their resignations so as to afford the members the opportunity of appointing successors. They had occupied office longer than was usual according to the precedents of other trade sections. He believed the rule was usually to elect new chairmen and vice-chairmen every two years. It ought also to be remembered that the post had been a serious addition to Mr. Crompton's numerous engagements. Mr. Crompton had rendered them service not only as the chairman of the section, but also to the whole electrical industry at large throughout the country. It had been a great pleasure to him to work with Mr. Crompton as a colleague. The one question alone to which he (the chairman) had referred—that of overhead wires—involved a great deal of trouble and anxiety. They received the resignation with great regret, but as Mr. Crompton's decision was irrevocable, he thought he would be in order in proposing that, while they reluctantly and with great regret accepted the resignation of Mr. Crompton, they should appoint a successor, and he would suggest the name of Major Flood Page, the senior vice-chairman of the section since its formation, and one who had devoted considerable attention to its affairs. Major Flood Page did not require any introduction from anyone. As chairman of the Edison and Swan Company he had had opportunities of being in touch with everyone in the industry. He had an intimate acquaintance with all the subjects that was likely to come before them, and he believed he was only serving the interests of the industry in proposing that he should be their chairman. He would also suggest that their chairman and vice-chairmen be appointed for a fixed term—say, two years.

This was seconded by **Mr. Musgrave Heaphy**, and on being put to the meeting it was declared carried unanimously.

Mr. Erskine proposed that Mr. Garcke should be re-elected vice-chairman. This was seconded by **Mr. Ebner** and agreed to.

Major Flood Page was sure that no one regretted more heartily than he did that Mr. Crompton should be retiring from the chair. It had been his pleasure on the day on which the section had been formed to propose the name of Mr. Crompton as chairman. He had urged that they should give a unanimous vote in his favour, and they did so, and he believed that the position that that section had occupied was very largely due to Mr. Crompton's influence in the electrical world. As the decision was irrevocable, however, he had pleasure in proposing the name of Colonel Raynsford Jackson as the second deputy-chairman.

Colonel Jackson thanked Major Flood Page for proposing his name as vice-chairman, but he declined the proffered honour, as he had not attended the meetings sufficiently often in the past, and he could not promise such an attendance in the future as would be befitting the position.

Mr. Alex. Siemens pointed out to Colonel Jackson that the duties of the second deputy-chairman would be very light indeed.

Colonel Jackson still declining to allow his name to be put forward, **Mr. Bennett** proposed that Mr. Alex. Siemens should be elected to the vice-chair. This was secondod, and on being put to the vote was carried unanimously.

Mr. Siemens said he had been somewhat trapped, as he had been approached by some of the committee a week before and had distinctly refused. He was reminded, however, by Major Flood Page, of his own argument to Colonel Jackson, that the duties would be "light indeed."

At this stage Mr. Crompton vacated and **Major Flood Page** took the chair. In returning thanks for his election, he said he could not of course pretend to be so fitting a representativo as their late chairman. Mr. Crompton was familiar with the whole professional as well as commercial aspects of the trade. He (Major Flood Page) represented the commercial side only. Ever since there had been a commercial aspect of electric lighting he had been identified with it. No one could deprive him of the honour of being the first to introduce electric lighting into New Zealand and other British colonies. He would do his best for the interests of the section, and he knew he would have the advantage of Mr. Crompton's experience should he require it.

The next subject to be dealt with was the consideration of the advisability or otherwise of the section following the precedent of other sections of the Chamber, in convening the whole of the membership of the section to all future meetings, abolishing the standing committee and electing special committees to deal with special subjects from time to time. The general feeling was that there could not be two opinions about the desirability of interesting the whole of the members in the proceedings, and the suggestion was, therefore, readily agreed to.

The attitude of the trade towards the Chicago Exhibition formed the next topic of discussion. The **Secretary** explained that the Royal Commission which had been organised to promote the interests of the British exhibitors at the Chicago Exhibition, had requested the Chamber to act as a London committee. The Chamber had accepted that duty, and, under ordinary circumstances, they should probably have requested the Electrical Section to consider whether it would take any special steps to be represented at Chicago. He understood that Mr. Preece, of the Post Office, had been occupying himself specially in that question, and perhaps it might be desirable that they should not appear to be interfering in his action.

Mr. Siemens thought that they could appoint a committee to confer with Mr. Preece for the purpose of ascertaining whether the section could be of assistance in the work.

It was agreed that Messrs. Wharton, Ravenshaw, and Binswanger, with the Chairman and Deputy-Chairman, *ex officio*, should act as a committee to confer with Mr. Preece.

The telephone question being the next subject for consideration, the **Chairman** said he was told by the secretary that nothing further had been done since the deputation had waited upon the Postmaster-General to urge the bringing in of a General Powers Bill to give the companies compulsory wayleaves.

Colonel Jackson said he had a few observations to make on the subject. They were all aware of the existence of an association for the protection of telephone subscribers, which professed to be affiliated with the Chamber of Commerce, but he thought that a recent circular which had been issued by the association would show that it ought not to be affiliated with the Chamber of Commerce. It had entered into special arrangements with the New Telephone Company on behalf of its members, and it had resolved itself into a canvassing body for the benefit of the New Telephone Company. The members of the association were to secure special privileges which were to be denied to the general public. The circular specially stated that no others would have the special privileges offered, and agreed to be given to the members of the association. In these circumstances he thought it was quite impossible for an impartial body like the Chamber of Commerce to allow of affiliation with it of an association which was practically nothing more nor less than a canvassing body seeking advantages for the members of the association at the expense of others—to assist one telephone company in opposition to another. Colonel Jackson then read one or two of the clauses from the circular referred to, agreeing to give a preference to the members of that association. It was clear to his mind that such an association could not be legitimately affiliated with the Chamber of Commerce.

The **Chairman** said he was informed by the secretary that a complaint had been lodged with the association as to the use which was being made of the name of the Chamber, and they had promised to withdraw its use in all future circulars.

Colonel Jackson did not think that that met the necessities of the case. He thought that an association which secured certain privileges for its members from a rival telephone company and secured them to the exclusion of the general public, and on the basis of these privileges resolved itself into a canvassing body for the benefit of one company as against another where a question of the public service was concerned, was not, in his opinion, entitled to affiliation with a fair-minded and enlightened Chamber of Commerce.

Mr. Jenkins understood that affiliation was denied (No! No!). In that case he was entirely in sympathy with Colonel Jackson's views. He was sure that the council of the Chamber must see that it was not to their interests that they should be made parties to patronising one scheme as against another.

Mr. Sydney Morse enquired whether the association complained of was represented at the meeting.

The **Chairman** replied that no association was a member of the section, though there were some individual members of the association, he believed, present at the meeting. He thought it was a subject for the council of the Chamber to deal with, and not for the Electrical Section.

Mr. Morse enquired whether Colonel Jackson was in order in bringing up the question.

The **Chairman** was clearly of opinion that he was in order, as the telephone question was on the agenda-paper.

Mr. Bennett said that Colonel Jackson had asserted that the object of the association was to canvass for subscribers to the New Telephone Company. That was not so. The real object and origin of the association was to investigate complaints which were brought forward by subscribers in London against the existing telephone service. The course they had taken in supporting the New Telephone Company was a consequence of that object. He thought Colonel Jackson had altogether overstated the case when he said that the object was to canvass for subscribers to the New Company.

Mr. Thompson thought that Mr. Morse had correctly pointed out that the agenda did not give a sufficient indication which would enable any member to have got together sufficient data to be familiar with the question. The secretary had already stated that the matter was in a fair way of being quashed. He thought Colonel Jackson had gone out of his way to exaggerate the importance of the question by making any reference whatever to the New Telephone Company. He suggested that nothing further be done, but that if the question should become of more importance it should be brought up with a proper notice on the agenda-paper, so that members who were interested in the association complained of would have an opportunity to attend and discuss the other side of the question.

Colonel Jackson regretted that he did not see Mr. Thompson, Mr. Haig, and some other members of the association at that meeting. He was quite certain if they had been, that as fair-minded and honourable men they would have seen the impropriety of the affiliation of the association with the Chamber of Commerce. He based his objections on the sentences which were in their own circular, and hence he had not gone out of his way to exaggerate the position. For these reasons he would move: "That a representation be made to the Council of the Chamber that it is not desirable that the Association of Telephone Subscribers, whose action is directed to obtaining from one of two rival companies special advantages for its own members alone to the exclusion of others, and which has constituted itself, for the above consideration, into a canvassing body, should be affiliated with the London Chamber of Commerce."

This was seconded by **Mr. Jenkins.**

Mr. Thompson moved an amendment, which was seconded by **Mr. Albright**: "That no action be taken by the Electrical Section in the matter of the Association of Telephone Subscribers and the New Telephone Company at the present time."

On being put to the meeting the amendment was declared carried, ten voting for and seven against it.

In reference to the question as to what attitude the section should adopt with reference to the Parliamentary Committee appointed to consider the question of electricity in London, it was agreed that the matter had been satisfactorily dealt with by the Special Parliamentary Committee, and that there was no need for any action by the section.

The report as to the action taken by the Chamber in reference to the question of overhead wires, and the reply of the Board of Trade to the representations contained in the recent memorial was the next subject on the agenda-paper. The letter to the Board of Trade, and the reply, were read by the secretary, of which the following are copies:

"February 16th, 1892.

"The Right Hon. Sir Michael Hicks-Beach, Bart., M.P.,
"President of the Board of Trade, Whitehall, S.W.

"Sir,—I am desired by the council of this Chamber to forward to you a copy of a memorial which has been signed by the leading electrical engineers, as well as by representatives of all the principal electrical firms in the United Kingdom, as to the use of overhead conductors.

"The original signatures to copies of the memorial are in our possession, and can be forwarded to you if desired, but, having regard to the economy of your time, it was considered preferable to send you the text of the memorial, with a list appended thereto of the names and designations of the signatories.

"My council express the hope that the memorial may receive at your hands the careful consideration which, considering its

representative character, you will probably think it entitled to.—I am, Sir, yours most respectfully,

"(Signed) Kenric B. Murray, Secretary."

[COPY.]

"Board of Trade (Railway Department), London, S.W.,
"February 23rd, 1892.

"Sir,—With reference to the letter addressed by the London Chamber of Commerce to the President of the Board of Trade, enclosing a copy of a memorial signed by a large number of electrical engineers and representatives of electrical firms in the United Kingdom, urging that this department should not lay down as a settled principle that no overhead conductors for the supply of electric energy should be allowed, but that, in rural districts at least, the circumstances of each particular case should determine whether overhead work should or should not be sanctioned, I am directed by the Board of Trade to say that the memorial in question appears to have been prepared under a misapprehension of the practice of this department.

"The Board of Trade are of opinion that, as a general rule, the use of overhead wires is accompanied by many disadvantages, both as regards the safety of the public and the efficiency of the supply of energy, and they think it is most desirable that mains for the supply of energy under provisional orders or licenses should, wherever practicable, be placed underground.

"They have not, however, laid down any absolute rule that overhead wires should in no case be employed, and while they have declined, in the absence of any special circumstances, to approve of a system in which the use of such wires was contemplated as a permanent arrangement in the central and populous portions of a town, they have, on various occasions, where the circumstances appeared to justify it, and the local authorities approved, authorised the employment of overhead wires in rural districts, or the outlying or less populous portions of towns.

"The Board of Trade see no reason to depart from the practice they have hitherto adopted of considering each application for permission to use overhead wires on its merits, having regard to the special circumstances of the district.—I am, Sir, your obedient servant, (Signed) Henry E. Calcraft.

"The Secretary, London Chamber of Commerce, Botolph House, Eastcheap, E.C."

Mr. Crompton said that with regard to the reply from the Board of Trade, of course if it were taken literally it would put them in rather a foolish position. It would appear as if they had been at great pains to prepare a memorial for which there was no cause. It was difficult to understand how the Board of Trade could have penned such a letter in face of the fact that it was at their own request, made in the presence of himself and another member of the Chamber at an interview at the Board of Trade, that the memorial had been prepared. An informal meeting took place at the Board of Trade, when he and the other gentleman who complained of the action taken in reference to overhead wires had for answer that the regulations might be modified if they could ascertain that the great body of the trade were against the regulation, and a suggestion was conveyed to them that if the great bulk of the trade were against the regulation it would be well to memorialise the Department. He only gave that explanation to justify action which without that explanation would seem, according to the Board of Trade, to be unnecessary. They had achieved what was aimed at, and it was better not to go further into the matter.

With reference to the by-laws made by the County Council in pursuance of the London Overhead Wires Act, 1891, which was the next subject considered, the **Secretary** stated that some months ago the members had been circularised on the subject, but only a few replies had been forthcoming, so that there did not seem to be many interested.

Mr. Gaines (National Telephone Company) said that these by-laws had been framed by the County Council, but they could not come into force until they were confirmed by the Board of Trade. The Board of Trade had made an appointment to consider them, and to consider the petition of all parties who had any petition to make on the 20th of June. The question was one which not only affected the companies who were running wires overhead, but it was a large public question as well, and he would venture to move that a small committee should be appointed for the purpose of considering these by-laws and also for the purpose of hearing the interests affected. It might be that the objections which were being brought forward by the companies who were running these wires might be very right and proper.

This proposal was seconded by **Mr. Bennett**, and on being put to the meeting it was unanimously agreed that Mr. Gaines, Mr. Bennett, and Mr. Edmunds should be appointed a special committee.

The next question—electrical communication on the coasts—it was felt was being satisfactorily dealt with by the President of the Board of Trade. It was agreed as far as possible in any questions of mutual interest to co-operate with the Mining Section of the Chamber.

A lively discussion ensued as to the question of electrical traction. **Mr. Morse** moved that a special committee should be appointed to consider the question, and to see whether the claims of the two interests could not be amicably adjusted, and to report to a future meeting of the section. In support of this motion, he said that there had been for some time a movement in the direction of the formation of some association for the purpose aimed at in his motion. It had been suggested that if a special committee of that Chamber were formed to discuss the subject it might appeal to a wider body, and it would have the advantage of being impersonal in its objects.

Mr. Garcke seconded this. He considered that it was a question of the utmost importance, not only to the section, but to the industry in general. A proposal had been made that there should be an association formed for the purpose of dealing with the question of electrical traction, but he considered it quite unnecessary. He thought that there was an unnecessary tendency to form separate associations, which involved expense to all who joined, when he thought it could be very well avoided, and, besides, they could not have the same standing in a separate association as they would have under cover of the London Chamber of Commerce. He therefore received with considerable satisfaction Mr. Morse's proposal. One important question he thought arising out of the motion was the appointment of a special committee. The constitution of that committee, he would venture to suggest, should not be too hastily decided upon. It was desirable that the gentlemen who had contemplated the formation of a separate association should be consulted, and if they would they should serve on the special committee. As it was difficult for them to determine at the meeting who were the most qualified to serve on such a committee, he would suggest that the matter might be left to the chairman and deputy-chairmen to consider, and to report the names at the next meeting of those whom they would recommend for nomination.

Mr. Morse expressed his willingness to add that to his resolution.

Mr. Gaines said that the unfortunate telephone company was again coming in. He wanted to understand what the motion really meant. The question was a very serious one, and he did not want to suggest whose business it was to find the remedy, but no doubt most of them were aware that the question had been thrashed out again and again before Parliamentary Committees, with the result that protective clauses had been inserted in the interests of the telephone companies in the various electrical Bills. He wanted to know if it was the intention to reopen the whole field, or whether it was proposed to be more limited in its character.

Mr. Thompson supported the remarks made by Mr. Gaines. He did not think that the section should commit itself to any decided line of action upon a snap resolution such as had been proposed in a very offhand manner. While he thought it desirable that the Chamber should take some action, yet in proportion to the strength of the Chamber as it had been described, so it was important that they should not take any action without careful consideration of the subject. The question was not on the agenda-paper, and, therefore, they could not have come prepared to discuss it. He would propose as an amendment that the matter be left over till another meeting, so that they might have time to consider it, and nominate gentlemen to serve on the committee at the next meeting who would be best able to represent the important interests involved.

Mr Crompton said he was prepared to take some blame to himself for this matter having been brought forward. He had heard that an association was being formed which he thought would be antagonistic to the telephone interest, and it occurred to him that it would be better if the whole question could be looked into from both sides by a full committee, which should consist of members of both interests, and that they should really see if a *modus vivendi* could not be arrived at by a number of business men instead of fighting their interests through the medium of lawyers and electrical experts. He was firmly of opinion that any great delay in bringing such a committee as that proposed into existence might be the cause of a great expenditure of money, loss of time, and irritation between the two branches. He thought the telephone interest should be very fully represented on such a committee, and by the very best men, just as in the same way as the other traction interests should be represented by the best men, and in such circumstances he did not see what was to hinder them arriving at a satisfactory settlement of the question. They knew what was referred to. It was the use of the earth. The question was going to be fought out on the Continent and in America, and he thought they would only show their good sense if they made an attempt to settle it in this country in a friendly way. He was delighted to hear Mr. Morse's suggestion that a committee should be formed, and he could not see that there was anything to be gained by delay, and possibly a great deal to lose.

Mr. Gaines would have liked very much to be able to fall in heartily with Mr. Crompton's views. The question, as he had said, as between the telephone companies and the electric traction companies had been fought out in Parliament during the last two or three years over every electric Bill, and a protective clause had always been inserted for the benefit of the telephone companies. Although he did not for a moment oppose the appointment of a committee as had been suggested, and while he was willing personally to attend and to take any part in the proceedings, he could not go to that committee with any suggestion that as far as the telephone companies were concerned the subject which had already been adjudicated upon by Parliament could be regarded as an open question. He could not tie his hands behind his back and say that whatever decision the committee might arrive at, they (the telephone companies) would be prepared to be bound by. An action was in progress at that moment where even without statutory protection the question was being raised under common law whether the telephone companies were not entitled to protection. The point was—which of the two branches were to double their wires. That was the English of it. Let the committee be appointed, but they must please understand that, so far as the National Company were concerned, they could not attend the committee with any suggestion that they would depart from the position which they had taken up before the Courts and before Parliament.

Mr. W. Worby Beaumont thought that the remarks made by

Mr. Crompton and Mr. Gaines lent importance to Mr. Thompson's motion. They should not be in too great a hurry to add to the responsibilities of the chairman and vice-chairmen in asking them to nominate a committee to sit on such a large question. He did not gather that Mr. Thompson was in any way opposed to the formation of a committee, but thought it should be formed after careful deliberation. He therefore seconded Mr. Thompson's proposition.

Mr. Morse thought that many of the members had entirely failed to grasp what was proposed. They had overlooked the important point as to what powers the committee would have. Mr. Gaines had spoken as if by joining the committee he was bound to carry out whatever decision the committee came to. Unfortunately, or, rather, fortunately, perhaps, the committee would have no such power even if they desired it. The committee were simply to be asked to consider and report on the matter. Assuming that both sides were represented, and came to a decision as to what is to be done, they would have got so far and probably got to something practical. He had foreseen for some time that traction by electricity was almost impossible, owing to the great expense, if the telephone company had excessive use of the earth. There seemed to be a basis for some arrangement between the two parties. They had, it was true, fought every traction Bill in Parliament, but they knew at what expense. They were spending a fortune on these legal proceedings. The telephone company said the matter was settled, but they were at present trying another action-at-law. If the telephone companies as a whole were represented, and the other side also, did they mean to say that no middle course could be arranged? That had been the object of the proposed association, and it would be the object of the committee.

Colonel Jackson said that he had listened with considerable interest to what had been said by Mr. Crompton, and he concurred in thinking it desirable that representatives of the two interests should meet in friendly conference, but of course, as Mr. Gaines had observed, the telephone company would not undertake to give up as a preliminary what had been established as its legal rights, and to give up which would be to lay a great industry prostrate before another.

The **Chairman** said that no one could dream that anyone agreeing to serve on the committee thereby gave up anything in the shape of legal rights.

Mr. Thompson said he would modify his proposal, to the effect that the chairman and deputy-chairmen should be appointed, and meet to discuss the matter; but that the nomination of the other members of the committee should be left till the next meeting.

Mr. Alex. Siemens thought that proposal involved a frightful waste of time. If the section had confidence in their chairman and vice-chairmen, they should leave the other members to their selection.

The first part of Mr. Morse's resolution affirming the desirability of appointing a committee was put, and carried unanimously.

Mr. Crompton moved an amendment to Mr. Thompson's amendment, that the chairman and deputy-chairmen should be appointed a Special Electrical Traction Committee, with power to nominate the other members of the committee and to meet forthwith.

On being put to the meeting this amendment was declared carried, ten voting for Mr. Crompton's amendment and two for Mr. Thompson's.

The proceedings then terminated.

LEGAL INTELLIGENCE.

CLOUGH AND CO. v. NATIONAL ELECTRIC SUPPLY COMPANY.

Negotiating a Loan.

In the Court of Queen's Bench, London, on Wednesday, the case of Clough and Co. v. National Electric Supply Company came before Mr. Justice Day, sitting with a jury. This was an action by a firm of accountants carrying on business at Leeds against the Electric Supply Company, of Preston, to recover £121 17s. 2d. for auditing the accounts of the company for negotiating a loan of £3,000 upon debentures of the company, and for attending meetings of the directors at Sheffield and Barnsley. The defendants paid £70 into Court in satisfaction of the claim, and repudiated any agreement to pay the plaintiffs £50 for negotiating the loan.

Evidence was given by **Mr. Ford**, one of the plaintiffs, that in September last year, the company being in immediate want of a loan, applied to him, and he got a Mr. Beaumont to advance £3,000 on a debenture of the company, and a guarantee from two of the directors, the plaintiffs, and Mr. James, the solicitor to the defendant company. There was no agreement to do this work for nothing, and plaintiffs' charge of £51. 17s. was reasonable. Besides the 6 per cent. on the loan, Mr. Beaumont got a bonus of £150, and plaintiffs had one-eighth of that for guaranteeing the loan.

Evidence supporting the case of the plaintiffs was given by **Mr James**, solicitor to the defendant company.

For the defence, **Mr. C. H. Cobbold**, mining engineer, and **Mr. Dan Rylands**, colliery proprietor, of Barnsley, directors of the defendant company, said it was pointed out to Clough and Co. that the company were paying at the rate of 16 per cent. for this loan, and that they would not pay more than the £150 bonus. The plaintiffs were to negotiate this loan in return for out-of-pocket expenses, and on the understanding that when the company was in a good position they would be appointed permanent accountants.

At the close of the evidence, Mr. Justice Day gave judgment for the plaintiffs for the full amount claimed with costs.

COMPANIES' MEETINGS.

REUTER'S TELEGRAM COMPANY.

The twenty-eighth ordinary general meeting of the shareholders in Reuter's Telegram Company, Limited, was held on Wednesday at the Company's offices, 24, Old Jewry, E.C., Admiral the Right Hon. Sir J. C. D. Hay, Bart , K C.B., in the chair.

The **Chairman**, in moving the adoption of the report, said that the revenue from the telegraphic business showed no retrogression. On the other hand, there had been a large increase of expenditure for telegrams and agencies. The increase had occurred chiefly during the first half of 1891, when events of exceptional importance were happening abroad. The second half of the year had shown a very material improvement, which had been maintained up to the present time. In the opinion of the Directors, the results for the past year had been satisfactory. The lease of 25, Old Jewry, had been acquired for advertisement business, which might be said to be still in its infancy. He had every confidence that with a revival of financial and commercial activity, advertising would prove a lucrative source of income to the Company.

Baron George de Reuter seconded the motion, which was carried unanimously.

The retiring director, Baron George de Reuter, and the auditors, Messrs. Welton, Jones, and Co., were re-elected.

A vote of thanks to the Chairman for presiding closed the proceedings.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £2,449.

Brazilian Submarine Telegraph Company, Limited.—The Directors of this Company have declared an interim dividend of 3s. per share, tax free, for the quarter ended March 31, payable on the 24th inst.

Reuter's Telegram Company.—The Directors, in their report for the year 1891, recommend, after transferring £3,000 from the reserve fund to profit and loss account, a dividend of 5 per cent., leaving £98 to be carried to the next account.

City and South London Railway.—The receipts for the week ending May 29 were £713, against £768 for the same period of last year, or a decrease of £55. The total receipts to date from January 1, 1892, show an increase of £1,266 as compared with last year.

Woodhouse and Rawson United.—We are informed by Messrs. Woodhouse and Rawson United, Limited, that they have opened a branch office and show-room at 22, Rue Lafitte, Paris, which will be the chief depôt for their French trade, and all communications regarding same should be addressed to Mr. E. Kenealy, the manager there, who will give same his prompt and careful attention. Mr. E. H Cadiot no longer represents the firm in France. They have also now opened a fully constituted branch of their business for the Midlands at Minories, Birmingham, and have taken over the show-rooms there recently occupied by the Midland Electricity Company, together with the supply trade of that firm, who will in future devote themselves exclusively to the engineering and constructing department. This change has already proved of considerable advantage to the local contractors and other buyers of electrical material, as the stock is very complete.

Cambridge Electric Supply Company, Limited.—The prospectus of this Company is issued, with a capital of £50,000 in 5,000 shares of £10 each. The Directors are Sir B. C. Browne, D.C.L., Gerard Brown Finch, M A., David Munsey, Esq., Hon. C. A. Parsons, J B. Simpson, Esq., Geo. Whitmore, Esq., with one Cambridge Director to be selected subsequently. The Company is formed for supplying the electric light current to Cambridge. It is estimated that an expenditure of £25,000 will be required to enable the Company to commence operations on a proper scale. It is expected that the light will be turned on at the beginning of October next. The scheme is similar to the Newcastle and District, which has been in active operation a little more than two years, and has already paid a dividend of 5 per cent. on its ordinary shares, and placed a considerable sum to reserve. The maximum price per Board of Trade unit at Cambridge will be 7d. for private consumers and for street lighting 5½d. This price, however, will rise and fall according to a sliding scale, allowing of a maximum cumulative dividend at the rate of £8 per cent. per annum after making due allowance for depreciation and reserve. The terms arranged with the Corporation include power for the Corporation to purchase at the end of 21 years, 32 years, or any subsequent completed period of 10 years. If purchased at the end of 10 years, payment is to be made as a going concern, including goodwill.

German Elmore Company.—The report of the Directors of Elmore's German and Austro-Hungarian Metal Company, Limited,

for the 15 months ending December 31, 1891, states that the audit of the accounts has been delayed by the circumstance that the principal vouchers for expenditure have been in the hands of Government officials in Germany since October last, and have only recently been returned by them. At the first general meeting it was stated that the Directors were then negotiating for the purchase of lands, buildings, and water power in Germany. This negotiation was completed on the 4th of May, 1891. The price at which the lands, buildings, and water power have been purchased is £22,000. These properties have since been valued in detail by an official valuer, appointed by the German Government, at the total sum of 873,222 marks, equal to £43,661. In addition to this there had been expended upon machinery at the same date the sum of £6,610, making the total value, as to the larger part officially ascertained, £50,271. As it was found that difficulties existed in obtaining legal possession of real property in Germany by a foreign company, on October 7, 1891, the Board, having completed all the necessary documents in conformity with German law, established a company under the title of "Elmore's Metall Actiengesellschaft," with a nominal capital of 1,000,000 marks, equal to £50,000, and with its domicile at Cologne. In this company the entire capital is held by Elmore's German and Austro-Hungarian Metal Company, Limited, and its nominees, and the management is entirely in the hands of the directors. The official sanction and registration of the company by the Court of Commerce at Bonn were completed on the 26th of last month, and at the same time the official sanction was given for carrying on the business of the company. The manufacture of tubes and the coating of calico printers' rollers with copper have been commenced, and the first delivery of goods has been made. A proposal has been formulated and provisionally accepted by the principal holders of the debenture stock, by which arrangement, when fully carried out, the £50,000 of 6 per cent. debenture stock will be redeemed, and will be replaced by fully-paid 7 per cent. preference shares, such shares to be entitled to further dividends *pro ratâ* after the ordinary shares shall have received dividends of 10 per cent. per annum.

PROVISIONAL PATENTS, 1892.

MAY 23.

9719. **Improvements in electric lampholders.** Oscar Thomas Cooper, 179, Milkwood-road, Herne Hill, London.

9741. **Morgan and James's improved "Electric miners' lamp-lighter."** Fred John Morgan and William Rees James, 9, Railway-terrace, Blaina, Monmouthshire.

9745. **Improvements in and appertaining to telephone transmitters or microphones.** Ernest Frank Furtado, 48, St. Paul's-road, Camden Town, London.

9746. **Improvements for electro-telephonic receivers.** Ernest Frank Furtado, 48, St. Paul's-road, Camden Town, London.

9747. **Improvements in electro-telephonic switching apparatus.** Ernest Frank Furtado, 48, St. Paul's-road, Camden Town, London.

9758. **Improvements relating to the regulating of electric arc lamps.** Ernest Eugène Beauvalet and Léon Charles Beauvalet, 18, Buckingham-street, Strand, London.

MAY 24.

9799. **Improvements in apparatus and means for the electrolysis of alkaline chlorides which may be in conjunction with earthy chlorides.** Desmond Gerald FitzGerald, 46, Loughborough-road, Brixton, London.

9850. **Improvements in fans operated by electricity.** James Henry Pickup, James Bryom, and James Ashworth, 47, Lincoln's-inn-fields, London.

9863. **Improvements in electric signalling apparatus.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (The Electric Secret Service Company, United States.) (Complete specification.)

9883. **Improvements in commutator brushes for dynamos or electric motors.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles L. Coffin, United States.) (Complete specification.)

9891. **Improvements in electrolytic electro-meters.** Alexander George McKenna and Henry Townsend Weed, 35, Southampton-buildings, Chancery-lane, London. (Complete specification.)

9895. **An improved safety attachment for overhead electric wires.** William Wilson Horn, 151, Strand, London. (Charles D. Brown, United States.)

MAY 26.

9906. **Improvements in electrical switches, ceiling roses, fuses, and the like, and in the method of attaching the terminals thereof to the conductors.** Albert Vyvyan Pittar and Edgar William Beckingsale, 6, St. Swithin's-lane, London.

9910. **Improvements in the method of and apparatus for electrifying air, gas, or vapour for various useful purposes.** Charles Percy Shrewsbury and John Laskey Dobell, 57, Chancery-lane, London.

9932. **Improvements in electric meters.** Paris Eugene Singer, 6, Victoria-road, Kensington, London.

9941. **Improvements in electrical contacts.** Charles Henry Smeeton and Herbert Page, 63, Queen Victoria-street, London.

9947. **Apparatus for use in insulating joints in insulated electric conducting wires.** Reginald Haddan, 18, Buckingham-street, Strand, London. (Alexandre Grammont, France.) (Complete specification.)

9959. **Improvements in the construction of apparatus for electric search-lights and signalling purposes.** Theophilus Coad, 1, Quality-court, Chancery-lane, London.

9983. **Improvements in the method of and apparatus for propelling vehicles upon railways by electricity.** William Phillips Thompson, 6, Lord-street, Liverpool. (Elias Elkan Ries and Albert Henry Henderson, United States.) (Complete specification.)

10014. **Improvements in incandescent electric lamps.** Johann Melhardt, 45, Southampton-buildings, Chancery-lane, London.

10022. **Improvements in electro-telephonic apparatus.** Charles James Grist, 61, Chancery-lane, London.

MAY 27.

10059. **Improvements connected with tubular electric conductors.** Ernest Payne, 39, Victoria-street, Westminster, London.

10060. **Electric meter for recording varying quantities of electrical currents passing in equal time periods over or along a conducting wire.** George William Hart, 3, Buckingham-road, Harlesden, London.

10131. **Improvements in telephones.** Siemens Bros. and Co., Limited, and Frank Jacob, 28, Southampton-buildings, Chancery-lane, London.

10133. **Improvements in insulating attachments for the support of overhead electrical conductors.** Mathews Nogueira Brandao, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

10139. **An improvement in telephonic appliances.** Rudolf Lowenstein, 45, Holborn-viaduct, London. (Charles Ernest Weiss, Germany.)

10143. **Improvements in dynamo-electric machines and motors.** Frederick Henry Varley and Amelia Varley, 82, Newington-green-road, Islington, London.

10145. **An improved differential arc lamp.** Richard Holsten, 1, Queen Victoria-street, London. (Complete specification.)

MAY 28.

10189. **Improvements in electric motors and dynamos.** Henry Chitty, 13, Brackley-terrace, Chiswick, London.

SPECIFICATIONS PUBLISHED.

1890.

911.* **Electrical conductors.** Pitt. (Atherton.) (Amended.)

1891.

7954. **Electric call apparatus.** Poore.
8225. **Controlling signals by electricity.** Aspinall and Hoy.
10843. **Regulating electric currents.** Ferrand.
11294. **Telephonic exchange signalling.** Bennett.
11313. **Utilising electrical energy, etc., in rock boring.** Bolton.
11560. **Galvanic batteries.** Hardingham and others.
12726. **Electrical armatures.** Thompson. (W. Lahmeyer and Co.)
17849. **Electric light fittings.** Lea and others.
18097. **Galvanic batteries.** Souther.
22370. **Sea telephones.** Huber and others.

1892.

3030. **Lighting railway vehicles by electricity.** Lake. (Consolidated Car-Heating Company.)
4578. **Electric lamps.** Carey.
4691. **Secondary electric clocks.** Schweizer.
6119. **Electric railways.** Cattori.
6569. **Telephone cables.** Kinsbury. (Western Electric Company.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5⅝
Metropolitan Electric Supply	—	7⅜
London Electric Supply	5	⅞
Swan United	3½	4⅛
St. James'	—	8
National Telephone	5	4⅜
Electric Construction	10	6¼
Westminster Electric	—	6 1/16
Liverpool Electric Supply	5	5½
	3	3½

NOTES.

Salisbury.—Mr. Eynon has agreed to test the Salisbury fire station electrical apparatus for £5 a year.

Otley.—At the Otley Local Board it was decided that the residences of the firemen should be connected with the central station by electric bells.

Bury.—At the monthly meeting of the Bury Town Council, the site at Whitehead Bridge for the purposes of an electric lighting station was approved.

Walborough (Devon). — The Walborough Local Board are dissatisfied with their gas, and are intending making enquiries as to the establishment of their own gas works or other means of lighting.

Personal.—Mr. W. B. Esson, who has been associated with Messrs. Paterson and Cooper as their engineer and manager for nearly nine years, has sent in his resignation, and leaves the firm on the 30th of the present month.

Cleethorpes is a pretty little seaport town known as Sheffield-on-Sea. The Local Board find the town badly lighted as compared with other towns, and Mr. Hill has determined to bring up the question till something is done.

Telephones at Dundee.—The Works Committee of the Dundee Poorhouse have accepted the tender of Messrs. Westwood and Son, of Dundee, for supply and fitting of telephones in connection with the new hospital, the amount being £110.

Wrexham.—At the last meeting of the Wrexham Town Council the town clerk read a letter from the Board of Trade, intimating that they had extended the time for the Wrexham Electric Lighting Company to make its deposit until 14th August.

Kidderminster.—Proposals have been received by the Town Council from three firms for the transfer of the Kidderminster electric light order, and the subject has been referred to a committee to examine the several proposals and to report upon them.

New Telephone Company.—The Bill promoted by the New Telephone Company, providing for the dissolution of the existing company and for its re-incorporation, with enlarged powers, has been definitely withdrawn by the promoters for the present session.

Lytham Pier.—After having about £10,000 spent on it, Lytham Pier was reopened last week. No ceremony took place, it having been decided to have a demonstration at the end of the month. The installation of the electric light took place with great success.

Sutton Coldfield.—Mr. Mayes has informed the Sutton Coldfield Town Council that the Sutton Gas Company would relinquish and give up their business on the 29th September next. Consequently it would be necessary at once to make arrangements for the future lighting of the borough.

Conversazione.—Invitations have been issued to the members and associates of the Institution of Electrical Engineers by the President and Mrs. Ayrton for a *conversazione* in the galleries of the Royal Institute of Painters in Water Colours, 191, Piccadilly, on Friday, July 1, from nine till twelve o'clock.

Electric Lighting Ladders.—For the public electric lamps at Bray, in Ireland, Messrs. Heathman and Co., of Endell-street, London, are constructing one of their platform extension ladders to telescope from 18ft. to 33ft., while they have another of these useful adjuncts in hand for the installation at Victoria railway station.

Shaftesbury.—At the Shaftesbury Town Council last week, Mr. Whitehead stated that the gas was so bad in that town that a number of people had now taken to burning oil. The borough surveyor is to go into the matter, and for one thing purchase a testing apparatus.

Books Received.—"A Dictionary of Electrical Words, Terms, and Phrases," by Prof. E. J. Houston; second edition, rewritten and greatly enlarged; published by The W. J. Johnston Company, New York. "Telephones: their Construction and Fitting," by F. C. Allsop; second edition, revised and enlarged; E. and F. N. Spon.

Lynton.—The surveyor's report to the Lynton Local Board says that the electric lighting has been satisfactory during the past season; according to the contract the lighting ceases from May 15 to July 15. One member objected that the surveyor's opinion was more favourable than his own—let us hope, however, he saw through partial eyes. The bill for lighting, £21. 5s., was referred to the Lighting Committee.

Bucharest.—The Secretary of State for Foreign Affairs has received information from Bucharest that tenders will shortly be invited for various public works, amongst which are lighting by electricity and the establishment of an electric tramway. Further details in possession of the Government can be obtained on personal application at the Commercial Department of the Foreign Office, between 11 and 5 daily.

Bacup.—At the close of the Town Council meeting last week, a meeting of the Special Electric Lighting Sub-Committee was held, when the report of Mr. J. N. Shoolbred, who was engaged to advise the Corporation on the subject of electric lighting, was submitted and considered. It was resolved that the members of the sub-committee, along with the town clerk and borough surveyor, should visit Newcastle, to view an electric installation in operation there.

Electric Tramways at Chemnitz.—It is reported that the Town Council of Chemnitz has authorised the Allgemeine Company, of Berlin, to lay out a new tramway line, and arrange that the existing one shall be worked by electricity. The system of the company as established in the neighbouring towns of Halle and Gera is said to have proved successful, and it is anticipated that Chemnitz will derive considerable benefit from the new method of communication.

The Potteries.—Clough Hall, a well known pleasure resort in the Potteries, has received many recent improvements for the summer season. The grounds are to be illuminated by 500 electric lamps besides search-lights, and two screw steamers have been placed on the pool. If they had been electric no doubt they would be even better patronised. A grand reproduction of "Venice" is to be carried out. Mr. Owens is the electrical engineer who has superintendence of the installation.

Western Telephones.—Telephonic communication between Bude, Hartland, Clovelly, Morte, and Ilfracombe will be complete in a few days. Connection is being made to the coastguard station. Bude will be the terminal of this district, but it is understood that Boscastle, and places to the westward, will be similarly dealt with. It is exceedingly important, in view of shipping casualties along this coast, that Bude, Boscastle, and Padstow should be in telephonic connection with each other.

Lancashire.—The question of lighting is a pressing one in various Lancashire towns. Messrs. Hamer, Turner, and Atkinson have been appointed a sub-committee at Dalton (Lancs.) to consider the public lighting. At Askam

a committee has been appointed to obtain better lighting. Barrow and Ulverston have been nibbling at the question of electric light for some time; and really at Barrow, now one of the most important of the smaller towns in the North, some definite action should be taken.

Chicago.—The London Westinghouse Electric Company, writing to us on Tuesday, inform us that they had that day received a communication from the vice-president and general manager of the Westinghouse Electric and Manufacturing Company, of Pittsburg, U.S., to the effect that that company has been awarded the contract for the incandescent lighting of the World's Columbian Exhibition, to be held at Chicago in 1893, after severe competition. They understand the contract covers apparatus to the extent of about 90,000 16-c.p. lamps capacity.

Electricity for Caterpillars.—Carl Hering, according to the New York *Commercial*, has constructed a device for preventing caterpillars crawling up trees: "Alternate wires of copper and zinc are run around the trunk of the tree, at a distance of about ½in. apart. The casual caterpillar begins to mount the trunk of the tree and unlimbers himself with the confidence and vigour born of an impending feast. Presently he reaches the copper wire, pokes his nose over it, and lets another kink out of his backbone. Half an inch further up his front feet strike the zinc, the circuit is completed, and the unfortunate larva is a martyr to science."

Original Morse Exhibit.—An exhibit of striking historical interest will be shown at Chicago by the Baltimore and Ohio Railway in the shape of the original apparatus employed in laying Morse's first telegraph wire. It is not generally known, perhaps, that Morse's first line was laid underground, from Washington to Baltimore. A heavy plough was procured with a reel rigged up behind, and from this the lead-covered wire unwound itself, and was covered up in the furrow. The leakage to earth, however, proved too great, and overhead wires afterwards came into use. The skins of 16 oxen stuffed will represent the original team, and wax figures of Prof. Morse and his associates will complete this interesting scene.

Derby.—We have already mentioned that the Derby Electric Lighting Committee had been definitely advised by Messrs. Bramwell and Harris on the relative advantages for electricity-generating purposes of several sites, including that of the destructor. The electrical engineers advised the adoption of the site in Silk Mill-lane, and the committee acquiescing requested that these lands be placed at their disposal. The Mayor, at the meeting last week, explained that the site selected was considered by experts to be the best in the town, and it would afford accommodation for plant sufficient to illuminate the whole town with electricity should it be considered desirable. Mr. Alderman Hobson seconded the proposition, which was carried.

Chiswick.—At the meeting of the Chiswick Local Board last week the report of the special committee was considered upon the tenders for the supply of electric light in Chiswick. The clerk said that the committee had gone very carefully through Messrs. Bourn and Grant's specifications, and had made certain alterations therein. They also recommended that the firm provide a new schedule of the engineering works, with particulars of the lighting, and that it be then submitted to an expert to advise the Board upon. In a brief discussion that ensued, it was thought that the fee asked by an expert—the amount of which, however, was not mentioned—was too high, and at the clerk's suggestion the matter was referred back to the committee.

Kimberley Exhibition.—The South African and International Exhibition, which is to be opened at Kimberley in September, is to be lighted entirely with the electric light. For the extensive grounds of the exhibition and interior of some of the principal buildings arc lamps are to be used. These will be worked from three Manchester dynamos, each for an output of 900 volts 10 amperes. The total number of arc lamps to be used is 37, each of 2,000 c.p. The interior of the smaller buildings will be lighted with incandescent lamps of 16 c.p., worked from three Manchester dynamos, each for an output of 110 volts 120 amperes. The whole of the plant, both for the arc lighting and incandescent lighting, is being supplied by Messrs. Mather and Platt, Limited, of the Salford Iron Works, Manchester.

Llandudno.—The well-known establishment of Craigside, Llandudno, has recently been fitted with a very complete electric plant by Mr. Wm. Kingsland, A.I.E.E. The installation comprises both arc and incandescent lighting, and also electromotors for working the laundry and hoist. A set of storage batteries of the E.P.S. K 19 type supply an adequate reserve, and are also used for the motors during the day and for a supply during the night, so that the light is available in the bedrooms at any time. The public reception-rooms have been brilliantly and tastefully lighted, the enterprising management having spared no trouble or expense in having the work done in a thorough and complete manner. Mr. Kingsland has personally supervised the work throughout, and the lighting has been most successful from the commencement.

Dundee.—A meeting of a committee of the Dundee Gas Commission was held last week, when the members were engaged for fully an hour in opening the contracts for the new electric lighting station and apparatus. Ex-Provost Brownlee, convener, presided, and Messrs. Urquhart and Small, the Board's engineers, were present. A large number of offers were submitted from all parts of the United Kingdom. The contracts, however, were principally from English firms, although several were sent in from Glasgow, Edinburgh, and Dundee. Ultimately it was remitted to the convener and the electrical engineers to tabulate the offers, so that the Commission would be able to arrive at a decision at their meeting on the 5th. We understand that at this meeting the tenders were accepted, the amounts (which were the lowest) amounting to £20,442.

Indian Carriages.—Some luxurious railway carriages have recently been built by the Oldbury Railway Carriage and Waggon Company for an Indian prince, to the order of Messrs. Jos. Showell and Co., Indian merchants, of Birmingham. The cars are double-roofed to protect from the hot weather, most handsomely decorated in dark blue russia leather and old-gold, with plush curtains, and oxidised silver fittings. They are lighted throughout by electric light, each carriage containing 13 lamps of 16 c.p. The current is obtained from specially-constructed accumulator cells, which will supply light for about 10 hours with one charge. The electric lighting apparatus was supplied and fitted by Messrs. Bayley Bros., of Walsall, under the superintendence of Mr. Spurrier. The general impression in the carriages is of Oriental richness of effect, but carried out with real artistic feeling and without over-elaborate decoration.

Inventions.—"To manage a meritorious invention to a financial success requires as much skill as to produce it, and many inventors are very poor judges of honest business managers. If an inventor has a good invention of merit and desires means, the safe way is to go to some acquaintance of means, and he will have no trouble in securing enough to develop it and place it in the market." So says G. E. Emerson in the *Scientific American*. It is

probably the best advice that can be given. If a man will invent he will, and there's an end on't. But we noticed something in a recent utterance of Edison's that should make a good many inventors pause. If anyone has made money by inventions, one would think it might well be Edison. Yet he states he never really made so much as a penny out of his inventions: he always lost as much on useless ones as he made on the saleable inventions. All the money he has made was obtained, he said, not by sale of inventions, but by manufacturing.

Electric Sailing Gig.—At the new electric launch works, Eel Pie Island, Twickenham, an electrically-propelled gig is being laid down. The boat is to be built in bright cedar, and is designed to give a mean speed of 6½ to seven miles an hour with one charge of about five to seven hours' duration. She will be fitted with awning, cushions, electric light, electric bell, gunmetal rowlocks, and sculls varnished and decorated—fitted above the gunwale (which forms a rail fore and aft), with a balance lug sail forward and a jib-headed mizen aft. The accumulators will be sealed and placed below the water-line, forming ballast and giving great stability for sailing. This boat, therefore, can be rowed, sailed, or electrically propelled at pleasure. She is being built to the order of F. W. Hagelmann, Esq., of Granby-street, N.W., and will conveniently accommodate six passengers. This class of electric launch are produced for under a hundred pounds, and will be very useful little boats for the Upper Thames and canals.

Waterloo Electric Railway.—The Select Committee of the House of Commons, presided over by Sir John Kennaway, resumed last Friday the consideration of the Bill under which powers are sought by an independent company to construct an electric underground railway from Baker-street to Waterloo. Mr. Pember, Q.C., having replied for the promoters upon the whole case, the committee proceeded to consider their decision. They found that the preamble had been proved, but they were prepared to give a protection clause to the Victoria Hotel in Northumberland-avenue similar to the clause contained in the Central London Railway Act of last year. If the South-Eastern Railway Company desired to say anything with reference to the passage from Northumberland-avenue to Craven-street, the committee would on that point reserve their decision. New clauses were inserted for the protection of the Victoria Hotel and the Conservators of the Thames. The Bill was ordered to be reported.

Electric Lighting in Ireland.—Dublin and Bray are both getting behind time, writes an Irish correspondent, in the matter ef electric lighting. In Dublin, Messrs. Hammond and Co. promised to have the principal streets lighted on May 1; while in Bray, Messrs. Gordon were bound under a penal clause of agreement to have the Esplanade lighted on June 1 inst. In both cases, the pillars and most of the lamps are already in position; and in Bray the cable laying is nearly complete, while in Dublin this work is only just commenced. Referring to the pillars, says our correspondent, those erected in Dublin appear to give general satisfaction, being of neat appearance and ornamental design; while the pillars erected at Bray are not received with the same satisfaction, being simply plain metal columns, 20ft. high, with only two collars or rings to break the level surface from base to top. The "Brighton of Ireland" will probably eventually require something more ornamental for its share in supporting the light of the future.

Cable v. Electric Cars.—An article is published in the *Tramway and Railway World* for May descriptive of the wire-rope works of Messrs. George Craddock and Company, of Wakefield. The article deals with the manufacture of tramway cables, more particularly with reference to the approaching opening of the cable tramway at Brixton. We have recently reported the complete turn out of the cable tramway systems at St. Louis and at Grand Rapids, in the United States. It is almost inevitable, we think, that instead of the cable tramway extending in proportion to the extension of other traffic facilities, that it should fall off by reason of the continued progress of electric traction, and probably the best service that electrical engineers could do to themselves and the cable tram manufacturers would be to do all they could to ally themselves with such firms, in which case the transformation may well go on without the excessive irritation that often occurs with the introduction of new methods in advancing industries. We have already seen good results occur with similar *rapprochements* between electrical engineers and steam tram engine builders.

Counting Coins by Electricity.—In the Mint, it is stated in the Master's report just published, a new counting machine for telling bronze coin has been erected in the bronze store. It was designed by Messrs. Maudslay, Sons, and Field, Limited. The machine has four distinct sets of counting apparatus, each of which can be worked independently of the others, and when all four are in full work upwards of 3,000 pence can be counted per minute. The coin to be told is raised to the level of two tables placed on a platform by a lift worked by an electric motor, which also drives the counting machines. A pair of these machines is fed from each of the two tables, the coins passing from the table down an inclined iron plate forming a flat hopper, from which they issue in single file through a channel of appropriate width. They are then gripped by a pair of indiarubber driving wheels, which force the coins past the rim of a thin disc provided with recesses in its circumference to fit the circular edges of the coins. As the disc is thus made to revolve, the coins are pushed forward, falling into a bag placed to receive them, and continue to advance until the counting wheel is automatically stopped and the bag containing the coins is removed.

Electrical Lecture at Lahore.—The railway and electricity—these are the two forces that draw men together in all quarters of the world. We hardly know how it is that the mere fact that a lecture on "Recent Electrical Developments," given by Mr. E. E. Oliver, superintending engineer in the Government College, Lahore, should lead to inward reflections on the progress of civilisation—yet so it is. Lahore seems so far away to most of us, that the mere mention of a lecture in so remote though important town of our colonies, calls up a desire for greater and greater extensions of our colonial facilities — and what can do this better than the "recent developments in electricity"! Mr. Oliver had present Colonel Le Messurier, secretary to Government, Mr. Sime, director of Public Instruction at Lahore and other educational officers, and a considerable audience of students at the colleges. The desire of more information in India on electrical engineering problems was shown by the keen interest taken by the large audience in Mr. Oliver's lecture; and theory should be followed by practice, for many of the young men then present will have important positions under their control.

Electric Organ.—The adaptation of electricity to organ-blowing is a speciality of Mr. Hope-Jones, of Leeds, and the employment of his inventions seem to be extending. The latest addition to the list of electrically-worked organs is that of All Saints' Church, Bristol. In this case the organ stands in a chamber in the base of the tower, and a solid stone wall of nearly 3ft. in thickness separates the

instrument from the chancel. On account of the impossibility of hearing the organ, the choristers have hitherto not been able to sit in the chancel; but now portable keys are to be provided, and a small additional choir organ bracketed out from the wall above the choir stalls. The organist will be able to sit himself below the entrance of the chancel in such a position that he can hear each part of his instrument equally, and can see and accompany the choristers and the congregation to perfection. He will play upon the small detached organ in the chancel when wishing to support the choir, and upon the main organ under the tower when wishing to encourage congregational singing, or upon the two instruments combined as may be desired. The portable console or key desk measures only 3ft. 6in. by 3ft. 9in. in plan by 3ft. 8in. high, and is connected with the two organs by means of a single flexible cable of wires no thicker than a finger.

Reading.—At the monthly meeting of the Reading Town Council the following minutes with regard to electric lighting were read: "The town clerk reported that the draft of the proposed license to the Reading Electric Supply Company, Limited, under the Electric Lighting Acts, 1882 and 1888, had now been finally settled by him with Mr. H. F. Kite in the form in which the company would make application to the Board of Trade for the license, and that the special meeting of the Council, as the local authority under the Acts, for passing a resolution giving their required consent to the company's application to the Board of Trade for the license would be held. The town clerk submitted a print of the draft of the proposed license by the Board of Trade as settled, and stated that if, when the matter was before the Board of Trade, that Board proposed to make any important alterations in the draft before granting the license, he would take further instructions from the committee." The town clerk then submitted the draft license as settled. Alderman Monck moved that the consent of the Council be given to the license to the Reading Electric Lighting Company, and that they be empowered to supply electricity for public and private lighting purposes. Alderman Hill seconded the motion, which was carried.

Electrotechnics.—The receipt of the 1892 edition of a little book entitled "Bibliotheca Electrotechnica," compiled and published by Fritz von Szczepanski (London: Sampson Low), makes us more and more grateful that English is fast becoming the universal tongue—at any rate for scientific books—and we must continue to be grateful to publishers who help forward the "consummation devoutly to be wished." It is only this morning we received a long letter, couched in elegant English, from a Russian in Philippopolis, and here is another Russian gentleman, Mr. Szczepanski—perhaps he will excuse us if we say we wish we could pronounce his name—who is rendering great service in spreading the knowledge of English and American textbooks throughout the Continent. His little pamphlet contains a classified and descriptive guide to electrical books and papers published in English, French, and German—in the first place journals devoted to the science, some of which we ourselves have not heard of, for there are already over 70 of them in the various tongues. Then comes books on theory of electricity, on industrial electricity, history, bibliography, electricity in exhibitions, batteries, lighting, mining, lightning conductors, railways, military electricity, the law on electricity, electro-chemistry, electromotors, deposition, bells, domestic electricity, instruments, transmission, mains, dynamos, measurements, potential, static electricity, formulæ, telegraphy, telephones, transformers, and electric clocks. The "Bibliotheca" is published in St. Petersburg, Leipzig, Paris, London, and New York, and anyone who wants electrical books, or has any which he wishes included, would do well to glance at this polyglot classified guide.

Whitehaven.—A deputation from the Joint Street and Harbour Committees of the Whitehaven Town and Harbour Trust visited Preston last week to view the works and to obtain information as to the electric lighting of that town. The Whitehaven surveyor has prepared an exhaustive report on the subject, in which he states that the power of gas to be replaced by electricity is equal to 3,837 candles, which now costs on an average £1,000 per annum. This illumination he proposes to replace by electric light of a total of 15,000 c.p., about, or nearly, four times the present quantity of light. This would require about 21 e.h.p., or about 25 i.h.p. in the engines. This power would be all required for public lighting, and he proposes to increase the amount by about 50 per cent., and provide two engines and dynamos equivalent to about 38 h.p. each, thus making provision for supplying a limited number of private consumers, and in case the demand were found to increase, to lay down further plant in proportion to such demand. The surveyor proposes to light a central area, including the harbour. This area, he says, could be most economically worked on the low-pressure direct-current system, thus dispensing with expensively insulated conductors, wasteful transformers, and general danger to consumers, consequent on the use of electrical currents of a high voltage. The estimate of the total capital outlay necessary for the proposed alteration in the method of lighting the town is about £5,000, with an estimated annual working expenditure of £1,245. 13s. 9d. The estimated annual revenue is about £1,675, which is equal to a profit of £430. The surveyor concludes his report by saying that it will thus be seen that with a moderate demand by private consumers the proposed installation will at least be self supporting, and it is obvious that to the extent to which the light is adopted by the general public will the revenue be increased, and the working and fixed expenditure thereby reduced in proportion to the total revenue.

Electric Tram Chronograph.—We alluded at the time of the Royal Society *conversazione* to an electric chronograph, the invention of the Rev. Frederick J. Smith, M.A., of Oxford. The following account gives further details of the instrument, which is really one of the most interesting of the delicate applications of electricity: The instrument was devised to measure exceedingly small periods of time. It has been used in physiological research and work on the velocity of shot, and the determination of the velocity of sound in many gases and solids, at different temperatures. By means of the instrument periods of time varying from the $\frac{1}{4}$ to the $\frac{1}{20000}$ of a second can be measured. The instrument consists of a metal girder furnished with a T-shaped end; it carries two steel rails, and the whole is supported on the V-groove, hole, and plane system. A carriage, to which is fixed plate glass slightly smoked, runs on the rails on three gunmetal wheels—the carriage is driven forward either by a weight or by a coiled spring. In the earliest instrument of this class at the Science and Art Department, South Kensington, the carriage is driven by means of a weight, and is brought to rest by means of a leather-band brake. In front of the moving surface a heavy metal pillar stands, carried on the V-groove, hole, and plane system; it supports any suitable number of electromagnetic styli. The pillar has two motions—one of rotation and one of vertical translation. By the former the styli are turned out of the way of the surface when it is brought back for a new observation, by

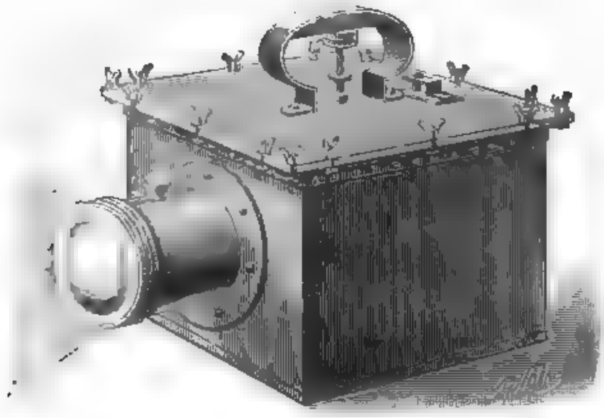
the latter the styli are at once brought into position for a fresh observation; thus a large number of observations can be made on the same surface. When the rails are adjusted with a certain amount of inclination, the traces of the fork are found to be practically uniform throughout their whole length. The time traces are measured and reduced by means of a micrometer microscope moving on a sliding frame; all observations are made from the bright line always to be found in the middle of the rougher marking of the stylus. When iridium-pointed styli are used the line is exceedingly fine and bright. Two kinds of electromagnetic styli are used. In the one marking is effected by the opening of the circuit, in the other by the closing of the circuit, the latter condition being required in certain experiments in physiology. The instrument is also furnished with continuous-contact breakers, whereby, when a photographic plate is fixed in the carriage, spark photographs of moving objects may be obtained in the manner suggested by Prof. Boys. This application of the instrument has been shown by the photographs of falling drops of liquid in air, and insects have also been photographed in this way. Mr. Smith's chronograph ought to render good service both in art and in scientific investigations in various fields.

Tramway Motors.—The exact necessary horse-power of the electric motors for tramways is a subject around which has always raged a considerable amount of discussion, and the matter was touched upon by various speakers before the Institution on the occasion of Mr. Reckenzaun's paper. Some little time before that an article had appeared in *Industries* seemingly maintaining that the power of the motors now used was excessive, and suggesting that with proper arrangement a 2-h.p. motor should be sufficient. We have had by us for some time an interesting letter dealing with this moot point, from Mr. W. Gibson Carey, the enterprising engineer who was in charge of the actual construction work for Mr. Graff Baker at the Roundhay Tramway. He says: "I have read the article to which you refer, and would say that the usual practice of suspending tramway motors with a bearing at one end on the axle and a flexible suspension from the truck at the other end, has proved itself entirely satisfactory. I do not consider that Mr. Field's plan of using a connecting rod with reciprocating motion any improvement whatever, and I must say that my experience has certainly not shown me the necessity to which the article in question refers, of mounting the motors on the car side of the springs. As to the main point in the article—viz., the use of a 2-h.p. motor instead of the much larger power usually employed—I would call your attention to the following figures: An ordinary 16ft. car, when loaded, weighs, exclusive of motors, about 10,000lb. At the rate of eight miles an hour it moves horizontally 704ft. per minute. Assuming that a pull of 25lb. per ton of weight is necessary to overcome friction (with a grooved rail it will probably be somewhat greater) the horse-power required to drive on a level road will be $\frac{4\cdot5 \times 25 \times 704}{33{,}000} = 2\cdot4$ h.p. If the same speed is to be maintained on a 5 per cent. gradient, the car must be lifted 35·2ft. in each minute, which will require, in addition, $\frac{10{,}000 \times 35\cdot2}{33{,}000} = 10\cdot66$ h.p. It will therefore be necessary to exert 13 h.p. to drive such a car at the rate of eight miles an hour, on a gradient of 1 in 20—a feat which is accomplished daily on scores of roads in the States. But when, in addition to the above weight, that of the motors is considered, the power required will be even greater. These figures are only for the power required to maintain the speed when once it has been attained. In starting, while the armature speed is yet very low, an enormous torque is required, and the motors must be designed to stand a current far in excess of that which will be taken when running at normal speeds. If Mr. Field's 2-h.p. motor will stand such overloads as this, it must be an unusually tough one. I trust these figures will set all doubts at rest."

Electric Light Engines.—The electric light industry has given rise to a special class of engine, in the highest degree economical, built for long runs, constant speed, and a very high degree of delicacy in regulation. The demand has caused a number of high-class firms to bend their attention to the question, and although up to the present the great Lancashire firms who build with such success the large slow-speed engines for cotton machinery have left the electric light industry largely to itself, yet another class of engineers, those who have gained special experience in steam launch and torpedo boat work, finding the problems usually put in installation work somewhat similar to those they are used to, have taken up with eagerness the new branch of engine building. Among these the firm of Messrs. G. E. Belliss and Co., of Ledsam-street, Birmingham, have taken an advanced place. Messrs. Belliss have not only carried out important contracts for the British, Indian, and Colonial Governments, but for the naval departments of the French, German, Italian, Russian, United States, and other Governments, and the experience so gained in ship, launch, air-compressing, and electric light work has enabled them to turn out high-class quick-running machinery developing very high power within exceptional limit of space. The attention they have given to electric light engines has, it would seem, resulted in the necessity for extension of their manufacturing plant in this direction, and all engines are tested on an actual installation with steam, under working conditions. Messrs. Belliss have recently, for the first time, gathered together the descriptions and illustrations of their machinery into a catalogue, which we should advise those interested in high-speed engines to obtain. The catalogue commences with a photograph of their exhibit at the Royal Naval Exhibition of dynamo engines constructed for H.M. ships "Crescent" and "Royal Oak," each of 34,000 watt capacity. Then we have an illustration of their simple open-type direct-acting engine, as supplied for driving dynamos on board H.M. ships "Alexandra" "Colossus," and the "Canning" and "Clive" of the Indian marine. A special feature is made of their central-valve dynamo engines, which are made both compound and double cylinder, and have replaced single-acting closed-in engines on board ship with much success. H.M. ships "Crescent," "Iris," "Leander," and others have been so fitted. This class of engine is termed the "Crescent" type. The central-valve vertical engine has been specially designed as an open-type high-speed engine for driving dynamos direct, and has been extensively adopted. The bearings are very large, the working parts a minimum, the arrangement of the slide valves requiring one eccentric and rod only. The cranks are set opposite each other, and steam being admitted simultaneously to the top of one cylinder and the bottom of the other the reciprocating parts are balanced, and there is no undue vibration at high speed. The engine is fitted with centrifugal or expansion governor as desired; in either case a variation of speed not exceeding 3 per cent. between full and no load is guaranteed. An enclosed double-acting high-speed engine is shown for dirty and dusty places, and, besides this, a number of wall engines, pumping and air compressing engines, triple marine expansion engine, and so forth, with boilers, make a most interesting catalogue to the engineering profession.

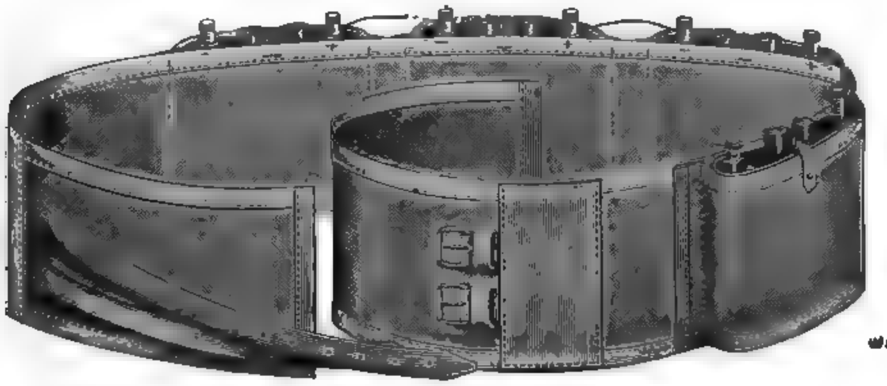
THE CRYSTAL PALACE EXHIBITION.

Amongst the primary batteries exhibited at the Crystal Palace, considerable praise should be given to those of the **Maquay Syndicate, Limited,** of 9, Frith-street, Soho, who have a stall full of applications of the Maquay battery



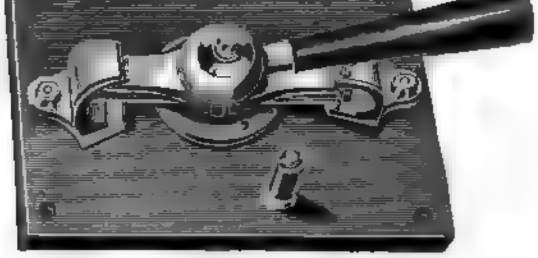
Maquay Diver's Lamp.

to portable lamps. Mr. Maquay has developed, to the most successful point that primary batteries have yet achieved, the application of his ingenious ideas for the production of small batteries of high E.M.F. He



Cathcart, Peto, and Radford's Belt, with Portable Lithanode Cell.

arranges a number of quite tiny electrodes of zinc, which can be sold at 4s. per gross, in suitable compartments, hermetically sealed or otherwise, containing the acid solution. This can be obtained either in liquid or mixed crystals for use. The peculiarity of the Maquay battery lies in its lightness and constancy. The lightness comes from the use of numerous very small cells, usually giving 12 or 20 volts, and the constancy from a peculiar preparation which partially covers up the zinc at first and afterwards peels off, exposing more surface. The weight of the miner's lamp is 3lb. 11oz. It runs for eight hours without failure in light and for three or four hours longer with a slightly failing light—say 10 to 12 hours in all. It

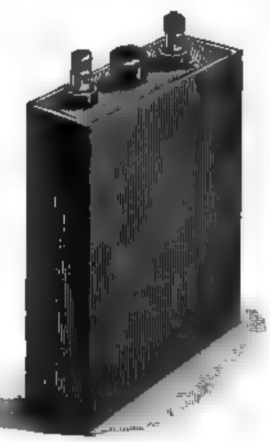


Cathcart, Peto, and Radford's Switch.

has stood actual test, and orders are in hand for several collieries both in the North and South. The diver's lamp, which we also show, is now in actual use and works well. It has also been used in powder mills and gas works. Mr. Maquay shows a neat guinea table lamp with primary battery in the base, also carriage lamps with separate battery, running eight hours, to place under the driver's seat. There are no wire connections in these sets, the lamps slipping into place with spring connections. A 14-cell battery weighs 12lb. only when charged. A separate battery for reading lamp is also shown. This weighs 25lb., and, it is stated, will run a 16-c.p. lamp for 8

Maquay Miner's Lamp.

to 10 hours at ¾d. an hour. In this there are 30 cells, giving 45 effective volts. Maquay batteries are shown for bedroom lamps, and also for medical and dentists' lamps. The same batteries are also shown



Pocket Lithanode Cell.

driving motors, and a model of an electric boat is shown. We are told that a full-sized river boat is shortly to be placed on the river, driven with a motor at 300 revolu-

Portable Table Lamp.

tions by one of these batteries. A large primary battery installation for 40 lights is also arranged, and an ingenious magnetic connection is used to throw the battery out of action by raising the zincs when all the lamps are turned

off. The most display, however, is made with hand lamps; and neat railway reading-lamps and cycling-lamps are now made by the Maquay Syndicate.

The firm of **Cathcart, Peto, and Radford** make a speciality in their exhibit of pocket secondary batteries. They use the lithanode secondary cells, of which we have frequently spoken, in combinations of their own. The single cell can be used for a tiny medical light or scarf pin, but a convenient arrangement is that of eight cells mounted in a belt to go round the operator's body. This gives a sufficient E.M.F. to obtain a good and steady light, and is an arrangement likely to prove exceedingly useful to doctors. A larger set of lithanode cells, fitted in polished wood box, is used for a table light, and makes a most convenient reading-lamp. The battery can be easily charged from a station circuit through an incandescent lamp. Messrs. Cathcart, Peto, and Radford also make some good switches with substantial contacts and double-rubbing surfaces. Smaller switches, cut-outs, and many other fittings are also made by them at their works in Hatton-garden.

METERS FOR RECORDING THE CONSUMPTION OF ELECTRICAL ENERGY.*

BY CHARLES HENRY WORDINGHAM, A.K.C., STUD.INST.C.E.

The rapid advance that electric lighting from central stations has made during the last few years has brought the question of the construction of instruments for recording the energy used by individual consumers into great prominence. The subject had engaged the attention of inventors for many years previously; but the need was not so pressing, and, numerous as had been the attempts, but few instruments had passed the experimental stage. Hence, the early supply companies were forced to charge their consumers a fixed price per annum based on an average number of hours of burning, such average being of necessity arrived at by guess-work in the absence of any experience. It was found that this system was unsatisfactory to the company and its clients, for in the case of clubs, restaurants, and many shops, three hours—the average time assumed—was found to be absurdly small; and, on the other hand, it was too large for many private houses. Endless disputes resulted, and consumers became dissatisfied and ceased to use the light. A large amount of loss was occasioned by persons leaving lamps burning needlessly, because they had not to pay for them; and it is a significant fact that in the case of a large central station in London, the current during the day was sensibly diminished when a large number of consumers were supplied by meter instead of by contract.

The urgency of the demand for meters has brought forth a supply, and there are now in the market several types that are reliable and accurate, and the author purposes confining his remarks chiefly to these, merely glancing briefly at a few of the best of the early and less successful types.

There are two fundamentally different systems of supply—*i.e.*, (1) by continuous, and (2) by alternating currents—and to each of these belong certain classes of meter that will only work with a particular kind of current, while some are common to both systems; these last are usually dependent for their action on the square of the current.

In all cases it is desired to measure the total amount of energy that has been converted into light and heat in the consumers' lamps and wires, and a meter is an instrument that continuously records the power delivered, and integrates it with respect to time.

In the case of continuous currents, if E be the potential difference, or pressure in volts, between the mains at any instant, and C the current in amperes at that instant through the lamps, then $E \times C$ is the power, or rate at which energy is being supplied in watts; and if t is the time in hours during which the rate is kept up, then $E\,C\,t$ is the total quantity of energy in watt-hours used by the consumer in the time t. This number divided by 1,000 gives the number of commercial or Board of Trade units (B.T.U.) consumed. What the meter has to do, then, is to sum up the successive values of this product.

* From the *Transactions* of the Institution of Civil Engineers.

With alternating currents the measurement of the power is not so simple, for in this case if the mean pressure and the mean current be multiplied together, the product is not necessarily the power absorbed. If the current lags behind the pressure, as it will if the circuit possess self-induction (and it always does so in practice, though in the case of a bank of incandescent lamps the lag is negligible), the current maximum does not occur at the same instant as the pressure maximum, and the real power is less than that obtained by multiplying together the mean pressure and the mean current. Taking the same units as before, if E be the maximum pressure, C the maximum current, and ϕ the angle of lag of the current behind the pressure,

$$\text{then the true power} = \frac{E\,C}{2} \cos \phi.$$

Since all distribution is effected at constant pressure, it is sufficient to integrate the current only, and to multiply the result by the pressure in the case of continuous currents, and of alternating currents also, if incandescent lamps only are in circuit, provided in all cases that the standard pressure is closely maintained. This course is adopted in a large number of meters, and is quite satisfactory in practice. If, however, greater accuracy be desired, the principle of the wattmeter must be employed. Here the stress between two coils, one of which carries the main current and the other a shunt current proportional to the pressure, is made use of. The force in the case of continuous currents is proportional to the product of the pressure and current; but in the case of alternating currents this is only the case if the shunt coil has no self-induction, a condition manifestly impossible to obtain; it can, however, be sufficiently reduced to render the error very small.

It would be entirely out of place in a paper of this kind, which aims at a description of actual instruments in commercial use, to enter into a mathematical discussion of the measurement of alternating currents, the matter being fully treated in text-books in language far more able than the author's, and to which he could add nothing.

Meters fall broadly into four classes: 1. Those in which the current to be measured, besides controlling the registering gear, supplies the motive power for it. 2. Those in which the current to be measured controls the registering mechanism, while a separate current supplies the motive power. 3. Those in which the current merely controls mechanism which is driven by some force altogether external to the current, such as a spring or weight. 4. Those in which no gearing is driven, but chemical action goes on, involving an alteration in mass of a plate of metal.

CLASS 1.

Numerous forms of motor meter have been designed, and some of the most successful instruments in use at the present time are included in this class. The majority are current, and not power-integrators, the pressure being assumed constant, as already explained.

Ferranti Meter.—This depends for its action on the fact that when a mass of mercury is cut normally by lines of magnetic induction, and an electric current flows radially through it, the mercury tends to rotate. If the same current that flows through the mercury excites the field, the speed of rotation will be proportional to the square of the current; but mercury being a fluid, its motion is opposed by friction against the sides of the containing vessel with a force that varies as the square of the speed, hence the speed of rotation is proportional to the current. This principle is equally adapted to the measurement of continuous and of alternating currents, and it has received very great development at the hands of the inventor. It is the meter that is chiefly used by the London Electric Supply Corporation for installations exceeding 40 amperes, and as the author has had a large experience of it, a detailed description may not be out of place.

When the principle is applied to making a practical instrument, an aluminium fan, mounted on a spindle, is immersed in the mercury, and is carried round by it; the spindle carries a pinion gearing into a train of counting wheels. This counting mechanism introduces friction that is practically independent of the speed of rotation, and is

greater when the meter is at rest than when it begins to move. The whole friction is thus made up of two parts, one varying as the square of the speed, the other independent of the speed; obviously the relative importance of the latter diminishes as the current, and therefore the speed, increases. In order to compensate for the error that would thus be introduced, a "shunt coil" is provided—*i.e.*, a fine wire winding on the field magnet placed as a shunt across the lamp leads—thus establishing a certain magnetising force independent of the number of lamps alight. The relative importance of this magnetising force manifestly decreases as the main current increases, and this effect is enhanced by a transformer action being set up, whereby the main current generates in the shunt coil an E.M.F. oppositely directed to that acting on it, thus further cutting down its magnetising effect. By suitably varying an extra resistance in series with the winding, the compensation can be made practically perfect. In Fig. 1 are

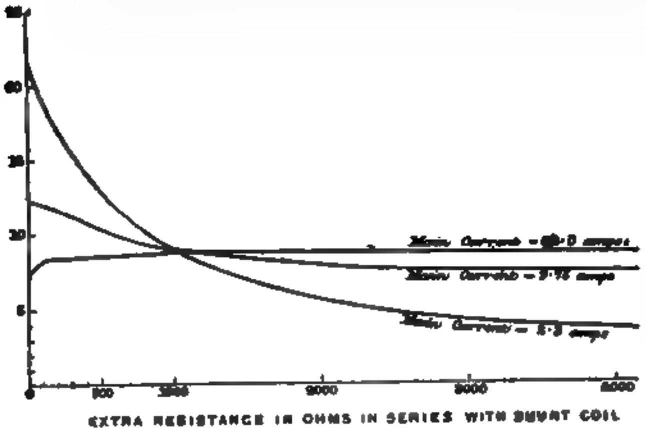


FIG. 1.

plotted three curves that very clearly show the part played by the shunt coil. A constant current was maintained through the main coil, and the current in the shunt coil was varied by altering the extra resistance in series with it, the speed of rotation for successive values of the latter being noted. Another value was then given to the current in the main coil, and the same operation repeated. The results are plotted for three main currents, revolutions per unit as ordinates, and extra resistance as abscissæ. It will be seen that except for very large shunt-magnetising forces the effect of the shunt coil at high currents in the main winding is small. The point in which the three curves cut gives the extra resistance required by the particular meter.

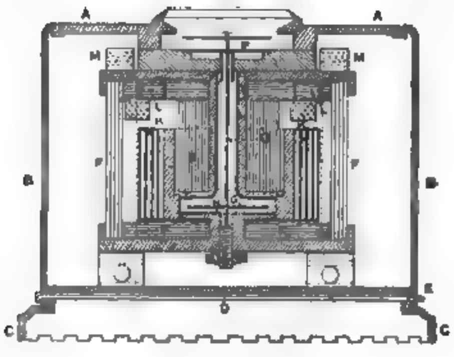


FIG. 2.

One of the latest forms of this meter is shown in Fig. 2. It is intended for a maximum current of 100 amperes, and with this load on for 24 hours does not rise to an excessive temperature. This, it may be noted in passing, is a point that should always be tried for each meter containing iron, if intended for alternating currents, for it is found that out of a batch of similar meters several will heat excessively. The cause is somewhat obscure, but is probably due to the laminations of the iron becoming short-circuited. The meter is contained in a well-ventilated brass case, A B C, no wood being used in its construction. The brass cylinder, B, is slipped on after the leads are fixed, and is secured by a wrought-iron pin, D, passing through it and under the base; a small hole, E, is drilled through the end of this pin, and tape is passed through this and sealed. It is thus impossible for the meter to be tampered with, and the whole arrangement is very compact and convenient. The magnetic circuit, F F, is closed, except for the gap, G, which contains the mercury. The current enters by the central portion, H, the rest of the top and bottom of the cavity being covered with vulcanised fibre. The circumference of the bath is uninsulated, and by it the current leaves, flowing thence through the main coil, K, one end of which is attached to the iron of the magnet, and so out of the meter. The shunt coil is shown at L, and the extra resistance at M; N is the fan, wholly immersed in the murcury, and carried by the spindle, O, which drives the train, P. The following is a test made of a meter of this type:

TEST OF 100-AMPERE ALTERNATE-CURRENT FERRANTI METER.

Meter started with 0·92 ampere.

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
1·5	10·4	40·0	16·9
3·0	15·4	50·0	17·0
4·0	17·5	60·0	17·3
5·0	17·3	70·0	17·3
7·5	17·5	80·0	17·3
10·0	17·0	90·0	17·3
20·0	17·0	100·0	17·3
30·0	17·2		

It will be noticed that the uniformity of the constant is most marked, and it has been found, after repeated experiments, that if the meter is adjusted so as to have the same constant at 10 amperes and 100 amperes, the value will be practically the same at all intermediate points. In the continuous-current form, solid cast iron or steel is substituted for laminated wrought iron, and the residual magnetism takes the place of the shunt coil. The following are tests of two of these meters:

TEST OF 100-AMPERE CONTINUOUS-CURRENT FERRANTI METER. UNSHUNTED.

Meter started with 0·25 ampere.

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
1·0	16·6	50·0	16·6
10·0	16·4	100·0	16·5

TEST OF 10-AMPERE CONTINUOUS-CURRENT FERRANTI METER. UNSHUNTED.

Meter started with 0·15 ampere.

Current in amperes.	Revolutions per B.T.U.
1·0	110
5·0	112
10·0	110

An important point in connection with the permanent magnetism of these meters, which renders its use unobjectionable, is that the steel giving the initial field is magnetised to saturation by the largest current the meter is intended to carry, so that every time the full load is on the meter the steel is re-magnetised, and any danger of falling off in strength of field is avoided.

In the latest form, meters of the same capacity are made to have the same constant by adjusting the width of a gap in the magnetic circuit, and by the introduction of suitable gearing the constant is dispensed with and the meter is rendered direct-reading. These meters are "double-sealing"—*i.e.*, the working parts can be sealed by the local authority against any possible tampering by the supply company, while the latter can independently seal the terminals in order to protect itself from fraud on the consumer's part.

Some of these mercury meters have been at work for two or three years without any attention, though it is desirable to clean the trains and mercury once a year. The following case will give some idea of the constancy that may be attained by this kind of meter. The meter, an alternate-current one, was installed on December 3, 1887, and removed on February 25, 1890, during the whole of which time it received absolutely no attention. It was, however, read weekly, so that its performance could be noted, and was constantly at work, except for one week, when it was removed from one consumer's installation—the consumer having ceased to take light from the company—and placed in another's. During the period named

the fan made rather more than 9,500,000 revolutions. The tests of the meter before it was put on the circuit, and after it was removed, are as follows:

TEST MADE BEFORE METER WAS INSTALLED.
Meter started with 0·8 *ampere.*

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
1·9	17·77	28·75	17·70
4·6	17·77	57·0	17·77
6·4	17·73	95·0	17·73

TEST MADE AFTER OVER TWO YEARS' USE.
Meter just failed to rotate with 2·17 *amperes.*

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
10·2	14·58	70·0	17·83
20·2	16·63	89·6	17·81
50·2	17·93		

The increased current required to start the meter, and the diminished constant at low currents, are obviously due to the train requiring cleaning. The constancy at the high currents is most satisfactory.

Forbes Meter.—Another meter that is adapted equally to alternating and to continuous currents is that invented by Prof. G. Forbes. It is based on the heating property of the current, and consists of a horizontal spiral of iron wire, over which is mounted, on a delicate pivoted suspension, a system of mica vanes. Convection currents are set up in the air by the hot wire, and these, rising against the vanes, urge forward the ring on which they are mounted, its motion being registered by a train of counting wheels.

The standard form at present made has a maximum capacity of 30 amperes, and the heated conductor consists of two concentric wires connected together by a number of fine wires. The current enters at a point in the circumference of one circle, and dividing between its two halves, flows by the fine wires into the other, and leaves by a point in its circumference.

In order to increase the starting power of the meter, a small weight is attached to a cord passing over a pulley and round a drum on the last wheel of the train; this tends to drive the train, and so gives the vanes less work to do.

This meter gave great promise when it first appeared, but it does not seem to have met with much favour, probably because, resembling, as it does, a laboratory instrument in delicacy, it is found unsuitable for practical work. It is liable also to be affected by external changes of temperature and by the temperature of its case not being uniform.

Hookham Meter.—This consists of a motor driven by the current to be measured, the motor being retarded by eddy currents set up in a copper disc. A tungsten-steel permanent magnet with cast-iron pole-pieces, provides a constant field, and in this is placed the armature, which consists of flat coils laid on a copper disc, the latter serving the double purpose of a support for these coils and of a brake, the latter effect being produced by the eddy currents set up in it. The armature spindle rests on friction-wheels, so that a small force will cause it to move, and with a view to still further diminish friction, mercury contacts are provided, instead of brushes, for the commutator.

The theory of the instrument will be plain from the following considerations. The work done in a given time is proportional to the attraction between the disc and the field, and to the speed. Now in a constant field the E.M.F. generated in the disc varies as the speed, and since this acts through a constant resistance, the eddy currents also vary as the speed; hence the work done is proportional to the square of the speed. The work supplied by the armature is proportional to the driving force and to the speed, but the driving force varies as the current; hence the work supplied in a given time varies as the current and the speed. But it has been shown that the work done is proportional to the square of the speed; hence it follows that the speed is proportional to the current.

The principle can be adapted to either alternating or continuous currents, but, so far, instruments for the latter class of current only have been constructed.

The meter is adjusted so that the dials show Board of Trade units, and it thus possesses the important advantage that its indications have not to be divided by a constant. This is brought about by varying the strength of the field in which the armature revolves, by short-circuiting more or less the magnetic circuit.

Some difficulty was experienced in passing the whole current through the mercury contacts, so that in the latest form all the motors are made to carry five amperes, and are shunted with a German silver resistance that allows the requisite proportion of current to pass. This is open to two serious objections—viz., (1) any error in the meter is magnified, since a portion only of the current drives the motor; (2) if the resistance of contact of the mercury varies (as it is almost certain to do), the motor does not get its right proportion of current, and its indications are therefore fallacious. The mercury being exposed to the air, and being subject to sparking, is rapidly oxidised, and in practice much trouble is experienced on this account, the meter requiring, after a time, a considerable current to start it. The permanent magnet is also an objectionable feature, though it is said that little change is found to occur in the field on account of the care taken in the preparation of the magnets, and because the gap in the magnetic circuit is small.

The author has not had the opportunity of testing any of these meters, but it is stated that a 20-ampere meter starts with 0·4 ampere; and that with 0·6 ampere the error is 25 per cent.; with 1·2 ampere it is 10 per cent.; while after 2·5 amperes the error is neglible.*

Elihu Thomson Meter.—Another meter closely resembling this in principle has lately been developed by Prof. Elihu Thomson, and appears to be free from some of its defects. A motor is provided, having its armature wound with fine wire and excited with a shunt current, and its fields, without iron, excited by the main current. Since the field is proportional to the current, and the armature current to the pressure, the driving force is proportional to the watts, and hence the instrument is a watt-hour meter. The opposing force, as in the Hookham meter, is due to eddy currents, generated in a copper disc, which is rotated by the armature in a constant field set up by permanent magnets. It is thus open to one of the objections to that meter, but is free from the mercury contacts and variable shunt resistance.

Falling off in strength of the permanent magnets is much to be apprehended, since they are under peculiarly trying conditions: the eddy currents, as in the Hookham meter, tend to demagnetise the magnets; and in the alternating form they are subject to the mechanical vibration which always accompanies this class of current. Another source of error is the friction of the motor brushes, which is likely to alter with wear and dirt.

Time alone can show the importance of these objections; there can be no doubt that when new the meter is capable of giving indication of great accuracy, as the following test proves (*see* Table A, next page).

In order to try the effect of varying the pressure as well as the current, the following tests were made of the same meter:

Current in amperes.	Pressure in volts.	Power in watts.	Revolutions per B.T.U.
24·8	108	2,678	9·96
20·1	108	2,171	9·96
15·2	108	1,642	9·72
10·0	108	1,080	9·66
24·9	90	2,241	10·14
20·1	90	1,809	10·02
14·9	90	1,341	9·66

The extremely low speed of the armature, and its property

* Since this paper was read, Mr. J. H. Tonge, Stud.Inst.C.E., has favoured the author with the following test of a 100-ampere Hookham meter for continuous currents. With pure mercury in the contact cups, the meter started with one ampere, and with 100 amperes it read 1 per cent. low; with 50 amperes, 4 per cent. low; with 20 amperes, 9 per cent. low; and with three amperes, 17 per cent low. When, however, ordinary commercial mercury which had been in use for a short time was substituted for pure, 3·5 amperes were required to start the meter, and with 100 amperes it read 8 per cent. low. This conclusively proves the statement made as to the error introduced by the variable resistance of the mercury contacts.

TABLE A.—TEST OF 25-AMPERE ELIHU THOMSON METER.
Meter started with 0·4 ampere.

Current in amperes.	Pressure in volts.	Power in watts.	Revolutions per B.T.U.
24·9	100	2,490	10·14
23·9	100	2,390	10·02
22·9	100	2,290	10·02
21·9	100	2,190	10·08
20·9	100	2,090	10·02
19·8	100	1,980	10·02
18·8	100	1,880	9·96
17·9	100	1,790	10·20
17·0	100	1,700	10·20
15·9	100	1,590	10·02
14·9	100	1,490	9·96
13·9	100	1,390	9·96
12·9	100	1,290	9·90
11·9	100	1,190	9·90
10·9	100	1,090	9·78
9·7	100	970	9·78
8·6	100	860	9·84
7·8	100	780	9·84
6·8	100	680	9·72
6·0	100	600	9·72
4·8	100	480	9·72
4·0	100	400	9·60
3·0	100	300	9·42
2·0	100	200	8·70
0·99	100	99	7·44
0·78	100	78	6·66
0·58	100	58	4·98

of stopping almost dead immediately the current is switched off, are noticeable points, and the former is an important advantage, as tending to lengthen the life of the meter by diminishing the wear.

In measuring currents supplied on the three-wire system, the neutral wire does not enter the meter, but the others pass each through one of the two field coils. The armature circuit is connected across the outer conductors, being thus excited with 200 volts.

When it is desired to measure the current conveyed by the high-tension mains from an alternating central station, the high-tension lead is taken through the field coils, while the armature circuit is excited by the secondary of a special converter, having its primary connected across the high-tension mains.

Ferranti-Wright Meter.—This is, in effect, an alternate-current motor, and depends for its action on one of those peculiar phenomena which take place when a conducting circuit is cut by lines of magnetic induction which are varying rapidly in direction and intensity. The meter is

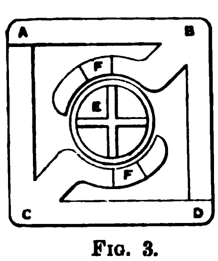


FIG. 3.

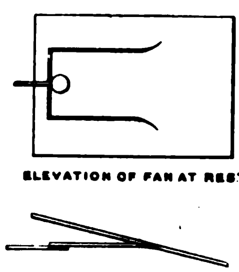


FIG. 4.

shown in plan diagrammatically in Fig. 3. The four limbs, A B, B D, D C, C A, consisting of laminated wrought iron, are wound so that B and C are opposite poles; each of these is fitted with a pole-piece consisting of an elongated horn, forming part of a circle, within which is placed a conducting disc, E, usually, but not necessarily, of iron. Each horn is surrounded by a closed conducting circuit of low resistance, consisting of one or more copper bands slipped over them, shown at F F. It is impossible to give a full explanation of this remarkable meter in a few words, but perhaps the following will make its principle fairly clear. Suppose a current to rise in the magnetising coils from zero to a maximum, then it tends to magnetise the iron, and the induction in the iron follows the successive values of the current in the part enclosed by the coils nearly instantaneously, but in the horns it lags behind the current, partly on account of hysteresis, but chiefly because its change generates in the circuit, F F, currents that tend to magnetise the iron in the opposite direction. The action of the closed copper circuit is to hinder the rise of magnetism in the iron, giving it a kind of magnetic self-induction in just the same way as iron gives to an electric circuit ordinary self-induction. Now suppose for a single rising current there be substituted a rapidly-alternating one, then any point in the horn will experience a series of waves of magnetism following one another, and successive points along the horns will be subject to waves of diminishing amplitude (for the maximum induction falls off towards the tips), differing in phase from one another on account of the lag above mentioned. The state of the induction in either horn at any instant may be represented by a curve, the lag being sufficiently great in some cases to cause the induction to be of opposite sign at the tip and at the root. There are thus, as it were, a series of tufts of lines of force travelling along the horns and brushing past the disc. Now these induce currents in the disc, and owing to its self-induction, the repulsive effect preponderates over the attractive, and the disc is repelled round. It is found that its speed is proportional to the square of the current, but by mounting radial mica fans on it, its motion is retarded by the air resistance with a force that varies nearly as the square of the speed, and hence the disc revolves proportionately to the current. There are two causes operating to disturb this proportion at the two ends of the range: (1) At starting, the friction of the disc spindle is relatively large, and the speed is lower than it should be; this is overcome by winding the magnets with a shunt coil that is just sufficient not to cause the disc to revolve. (2) At high speeds the air resistance depends on a rather higher power than the square of the velocity, thus making the speed somewhat lower than it should be. This is compensated for by slitting the fans as shown in Fig. 4, so that they yield somewhat, and thus expose a less effective surface. How perfect this compensation is, may be judged from the following tests of a 10-ampere and 20-ampere meter:

TEST OF 10-AMPERE FERRANTI-WRIGHT METER.
Meter started with 0·25 ampere.

Current in amperes.	Revolutions per B.T.U.
1·25	117·0
5·00	116·4
7·50	115·2
10·00	114·0

TEST OF 20-AMPERE FERRANTI-WRIGHT METER.
Meter started with 0·65 ampere.

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
2·5	117·3	12·5	115·2
5·0	116·1	15·0	116·2
7·5	114·3	17·5	114·5
10·0	114·9	20·0	116·4

(To be continued.)

ELECTRIC AND CABLE RAILWAYS.

The following memorandum, prepared by Lord Kelvin, forms Appendix A to this report:

1. Every part of the electrical system which is kept at a potential differing from that of the iron tube, should be carefully protected against accidental or intentional contacts, or disturbance of any kind by passengers.

[For brevity in what follows, difference of potential from that of the iron tube shall be called "pressure."]

2. Any part of the electrical system kept permanently, or liable to be occasionally kept at any pressure exceeding 300 volts, ought to be carefully protected against accidental contact, whether of passengers or of the company's servants. Hence the third or insulated rail ought to be overhead, and not in the bottom of the tube, between the two bearing rails, as it is at present on the South London line.

3. If the third, or insulated, rail is permanently or at any time in ordinary use kept at a pressure exceeding 500 volts, it, and feeders or other conductors directly connected with it, if there are any, must be insulated overhead.

4. This committee does not insist that in the particular case of the extension of the South London line the present arrangement with third rail below may not be adopted, but if it is adopted the pressure must on no account exceed 500 volts.

5. In each of the Bills before this committee there ought to be a clause protecting telegraphs and telephones against disturbance, similar to the clauses adopted for the Liverpool Overhead Electrical Railway, and for the South London Electrical Railway.

May 19, 1892. KELVIN.

NIAGARA AND ELECTRICITY.

The following letter from Prof. George Forbes, who is at Niagara, appeared in a recent issue of the *Times*:

"Sir,—It is now some eight years since I stood on the southern edge of the American Fall, less imposing, though more approachable than the Canadian or Horseshoe Fall, just above the Cave of the Winds, and, while watching the huge volumes of water within a yard of my feet leaping over the precipice, dreamed dreams. To-day I go over the same ground, and find my dreams within range of realisation. When I recall the number of poets and philosophers who have sat on the same spot and been inspired by the same incentive to thought, I should indeed be foolhardy if I were to attempt to describe my impressions of this marvel of nature. When I recall the apt language in which these thoughts have been uttered, sometimes in the columns of the *Times*, I would not put pen to paper were it not that some matters which occur to me may awaken a new interest in the gigantic cataract and may even point a moral. I will not try to describe, I will only repeat, as my individual experience, the fact known to everyone who knows this spot, that it grows on you like the sympathy of a true friend. It is always the same, but never two moments alike. Every hour of the day the sun strikes each part of the falls in a new direction, and each day in the year and each moment in the day the curtain of mist that rises from their base at the same time hides or encircles some new feature of the cascade, while the rush of the rapids and the deep boom of the falls vary with every point of view and with every change in the wind. An artist once said to me that a great part of the beauty of a scene comes from expectancy, wonder, and curiosity as to the unseen parts hidden by nearer objects. This is emphatically so with the mist under the Horseshoe Fall. No one was ever wearied by the monotony of this scene.

"When an astronomer wishes to give an idea of the distance of the stars, he begins with what is near and intelligible. He takes the case of the railway trains that go at 60 miles an hour, and he says that it would take 4,000 hours to travel to the moon, and so he goes on by steps. At the spot where I dreamt my dream eight years ago I was looking at a small portion cut off by a small island from the American Fall, perhaps a hundredth part of it, and the American Fall passes, perhaps, one-fifth of the water passed by the Horseshoe Fall, and following the astronomers, by dealing with a little bit which I was able directly to realise, I was more able to grasp the total power developed at this little spot on the earth. It was not then impossible to believe that 4½ million horse-power were being developed in the falls, or, as Sir William Siemens put it, the equivalent of all the steam power used in the world. As a plain fact, if it takes on an average 4lb. of coal to generate 1 h.p for an hour, this water power is the equivalent of 15,000,000 tons of coal per annum. But I was struck, not so much by the volume of water that was shooting down as by the immensity of the power of heat which is able to evaporate and carry to the great lakes by the winds a volume of water equal to that which I was able to see was passing. I then realised that this is the most gigantic condensing steam engine in the world of 4,500,000 h.p. The power in the falls acts as a furnace; the mass-velocity of the water acquired by the fall is arrested and converted by fluid friction into molecular velocity, which is heat; the lower river and the ocean form the boiler from which the heated water evaporates; the wind is the engine by which the steam is carried to the condensers, which are the great lakes. The work done is the work of raising a thousand million pounds weight of steam from the lower river and ocean to be eventually deposited in the upper lakes every minute of time—not necessarily the same atoms of steam, but their equivalent.

"When my dream had carried me thus far the spirit of the engineer arose in me. I quote from memory when I say that the charter of the Institution of Civil Engineers defines the province of the engineer to be 'to utilise the forces of Nature for the service of man,' a noble definition. In my dream I was filled with the aspirations which have moved so many at this spot, and a desire to bind a portion of this power and use it for the service of man. And now, eight years after, I see that the preparations are almost complete for the utilisation of 100,000 h.p., and part of this power will certainly be used long before the close of the year. Few people in England who have heard of this engineering feat are aware of how far it has advanced. More than a mile above the falls a canal has been cut, 1,500ft. long, at right angles to the river. A vertical shaft 140ft. deep is being sunk, and from the lower level a tunnel 28ft. high, and 18ft. wide, and 6,700ft. long, has been carried at a slope of 7 per 1,000, to issue at the foot of the cliffs below the falls, just under the suspension bridge. This work is all nearly completed. The lining of the tunnel with four courses of bricks is going on at the rate of 100,000 a day, and this rate is about to be increased. The turbines are in hand. Part of the power is to be used in factories now being built directly over shafts, and we are now preparing for the electrical transmission of power. In a year's time it is probable that the city of Niagara Falls will be lighted by this power and the street electric railways worked by it. Factories are being erected on the vast extent of land owned by the company which has a perpetual right to use this power over five miles of river frontage from a little above the falls upwards. Already 30 acres of land have been reclaimed by the company from the river, and the river is about to be deepened in front of their wharves. A railway five miles long, all passing through the company's land, is in hand to connect the three lines of railway with the principal factories on the company's property. This will eventually be worked by an electric locomotive. Streets have been laid out, and a part has been laid aside for operatives' cottages. All this I have seen, and I recognised the foundation of an important manufacturing centre. Franchises have been obtained from owners of property for a second tunnel under the city of Niagara Falls. All this has been done, and at a surprising small cost, by the energy, caution, and foresight of the directors of the company, of which Mr. Adams is the president, Mr. Wickes and Mr. Stetson vice-presidents, and Mr. Rankine (a cousin of Prof. Macquorne Rankine) the secretary. In 1890 they appointed a commission of leading scientific men in Europe and America, presided over by Lord Kelvin. These commissioners considered all the proposals submitted, and since then the company's engineers have dealt with all the hydraulic problems. The board of engineers includes the names of such men as Prof. Coleman Sellers, Mr. Herschel, and Colonel Turrettini, of Geneva. The electric part of the work is now to be carried out. In 1890, when preparing plans to lay before the commission, I proposed to employ alternating currents, using as motors either the alternating dynamo or the multiphase motor, which has since attracted so much attention at Frankfort last year. This was an innovation on previous practice, and it is worthy of record that the commission were unanimous (with one exception) in desiring to pass a resolution saying that alternating currents were not available for the purpose. Already opinion has changed, and the subsequent progress has so completely borne out the views expressed in 1890 that we are going to adopt this method.

"It may be that what I have already written may convince many of the enormous character of this undertaking. But the importance of the company's transactions has been only half told. They have lately acquired from Canada the exclusive right to use land in the Victoria Park for the same purpose for 100 years. The river above the Horseshoe Fall on the Canadian side has a branch going round Cedar Island. The power-house can be built here. Enough water can be brought through the branch to utilise 250,000 h.p., and the tunnel from the bottom of the shaft to the very base of the fall will only be about 800ft. long. This franchise is a most valuable addition to the powers possessed by the company on the other side.

"Many visitors to the Chicago Exposition next year will stop to see the progress of this gigantic undertaking, and they will not be disappointed, and it is a matter for congratulation that, so far as the present intentions of the company go, the beauty of the falls will not be affected nor the volume of water perceptibly diminished.—I am, Sir, your obedient servant, "GEORGE FORBES."

THE

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THREEPENCE.

The policy of St. Pancras is a bold one, but it has the appearance of being one that may prove eminently successful, and so is well worthy of trial. Our readers are aware that some time since the machinery at the St. Pancras central station was fully loaded with lamps during a certain part of the daily run. The output curves of this and every other central station, however, show that full load is only on during a small portion of the twenty-four hours. Ordinary manufacturers—and with them we must include the manufacturer of electrical energy—are not satisfied with having their machinery fully loaded about two hours a day, but prefer to have it fully loaded all day. The two schools of electrical engineers attempt the solution of the question in different ways. One contends that the proper method to employ is storage. A comparatively small plant, working always at full load, is used to store during the hours of little demand, and the store thus obtained is used to supplement the supply of the machinery during the hours of full demand. The problem of the economy of storage is very much on a par with that of the economy of mains. The other school repudiates storage, and at present rely on economical working by means of small units—the units being successively brought into action as the demand requires. Time and actual figures of results will prove which school is to survive, unless something more than the distribution of energy for lighting is brought into the problem. This is just what Prof. Robinson at St. Pancras is endeavouring to do. We have long since argued that the primary object of a central station may prove to be the distribution of energy for power purposes. It seems certain, however, that such distribution involves a second set of mains so as to interfere as little as possible with the pressure upon the lighting mains. The advantage of the supply of power is that the demand should be pretty constant during the working day, and this with overlapping ends is just the time when the demand for lighting is small. In a well-designed station for the supply of both light and power, the load on the machinery might be kept pretty constant. We assume that there is or will be a demand for power. Of course a part of the station management will be to take care that the machinery is not so loaded but that sudden demand due to fog or some other reason can be met. The St. Pancras authorities, then, in order to get a full load upon their machinery, not for one or two hours a day, but continuously and all day, have decided to supply current during the day service for power purposes at threepence per unit. Now there are hundreds and thousands of small users of power who could cheaply and conveniently obtain current for their purpose. The initial cost of a small motor is not great, and the cost of maintenance is very small indeed; in fact, may, in many cases, be left out of consideration. The great advantage of an electric motor is that the moment it ceases running it ceases to consume energy, and the meter registers nothing against the user. In the case of a small steam engine there is always a certain

consumption of fuel and some attendance required, and, together with the known lack of economy in these small engines, make up a cost which is hardly to be credited. The view is, no doubt, somewhat Utopian, but in the very near future we imagine motors will be nearly as common as blackberries—shoe-cleaners, knife-cleaners, sewing machines, ventilating fans will all be supplied. Hotels will have to fit motors to all these pieces of apparatus. One great field for the use of current will be in applying it to filters. As at present constituted, these articles of domestic use are merely separators of mechanical impurities, yet by a very simple addition—like that in Parker's patent shown at the Crystal Palace—not only can we get water mechanically pure—but by generating oxygen can thoroughly oxygenise the water as to chemically remove all oxidisible germs, rendering the water chemically pure, while at the same time filling it with oxygen gas, making it better than any of the sparking table waters which are so much in vogue. Every householder who uses the electric light will ultimately have his water not only filtered in the ordinary way, but supplementarily purified by electricity. In fact, if oxygen is as effective in destroying germs of disease as it is reputed to be, there seems to be no difficulty in rendering all drinking-water absolutely harmless as a carrier of disease germs. The cost to the householder to obtain this absolutely pure water, subsequent to the initial cost of the filter, would be far less than the cost of an eight-candle lamp. The amount of current required for such a purpose would be small, but collectively it should add to the load of the central station and assist the demand, which would make central station working more easy.

NIAGARA.

The utilisation of the water power from Niagara appeals to Englishmen more as another conquest or harnessing of Nature's powers, more as an abstract question rather than having any concrete bearing. It is very interesting to know that so many thousands or millions of horse-power can be obtained from the falls, but when, to utilise this hitherto wasted power, it becomes necessary to build a city and factories, many other questions have to be solved before the economy or the commercial aspect of the matter can be said to be known. Prof. Forbes's letter to the *Times*, reprinted elsewhere in this issue, is the letter of an enthusiast. No doubt the men who have put their money into the attempt to harness Niagara have examined into the question of whether factories are wanted, and more especially the kind of factories wanted at the point where this enormous power can be obtained. Factories could be erected and water power obtained in many places upon the earth's surface, but much more than the possibility is required before such speculations become commercially profitable. It is not long since a case came under our notice of a man of great experience running a factory to make an article in large demand for which he could obtain a ready sale at a price. He was, however, unable to sell at the price, because the cost of transporting the raw materials to and the finished articles from the factory was too high. The result was ultimately the closing of the factory and the usual whitewashing of the merchant. Thus, before we can enter into a full consideration of the value of obtaining power from Niagara, we must have information as to the proposed manufactures, and whether the position of the factories is such as to warrant commercial men embarking capital in starting such factories. The methods carried out to utilise this enormous water power will be watched with keen interest, and when the details are fully known they will appeal to every electrical student. The conception of the work and the carrying it out demand the heartiest approbation, and it is to be hoped that the result will be as successful as the greatest enthusiast can desire. If naturally the position is not a good commercial one, this attempt will, at any rate, assist to solve a problem, whether under certain conditions it may not be more profitable to go to the natural power rather than to a position more favourable in other respects, but where artificial power has to be used. The result must, we think, depend on cost of transport to and from the point.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE MAGNETIC BOOT.

SIR,—The magnetic boot is an old dodge. It was exhibited at the electrical exhibition at the Crystal Palace 11 years ago. The magnet was in the sole, and the man had 20 or 30 little compasses on his counter, and when he passed the boot (a lady's very neat patent leather boot) over the compasses the effect on the needles was wonderful. I took a fancy to the compasses, and I persuaded the man to sell me one, and I made a galvanometer of it. I don't know that anyone bought the boots, but there are plenty of fools in the world, and people who will buy belts will buy boots.—Yours, etc. X.

MEDICAL ELECTRICITY.

SIR,—My attention has been called to your remarks on the above subject in a recent number of the *Electrical Engineer*, in which you seem to doubt that "toothache, deafness, and even blindness" can be cured by means of electricity, and you observe that Prof. Geismar "must be a peculiarly able manipulator of nerves, or his audience peculiarly credulous," though I think the good folks in Aberdeen are too far *north* to be easily imposed upon.

May I be allowed to say that Mr. Grigg, the celebrated medical electrician of Eastbourne-terrace, has cured all these complaints long before the "Professor" was ever heard of. In the year 1866—when probably the "Professor" was learning his A B C—Annie Robins, of Plymouth, who had been blind for over 20 years, had her sight restored by means of Mr. Grigg's treatment; and in 1876, K. Alderman, of Stonehouse, who had been deaf for 15 years, was perfectly cured, and many other cases could be given if necessary. Toothache also can be instantly cured by electricity. If sufferers would only give Mr. Grigg's system a trial they would soon obtain relief and be ultimately cured.

All the leading medical men in London and elsewhere are well aware of the many marvellous cures made by Mr. Grigg from time to time, in cases which have been given up by the faculty as incurable; but it is not to their interest to admit this. On the contrary, they do all they can to keep Mr. Grigg's treatment *dark*, and try to frighten patients who enquire about it, and say it is very dangerous

to heart and brain; but there is no danger whatever, and *shocks* from Mr. Grigg's far-famed electromagnetic machines are unknown.

Trusting you will give publicity to this letter in your next issue—Yours, etc.,
DAVID RODAN.

13, Upper Montague-street, W., May 25, 1892.

ARMATURE STAMPINGS.—A correspondent wants to know the names and addresses of makers of armature stampings.

REVIEWS.

Berly's Universal Electrical Directory. Eleventh year of publication. Alabaster, Gatehouse, and Co., Paternoster-row. 4s.

This directory, in the hands of new publishers, may be said to have taken a new lease of life. It now fills over 750 pages, and, without considering supplementary matter, is divided into three parts or sections dealing respectively with the Continent, America, and Britain. Each section gives first an alphabetical list of names, then a classified list of trades. Of course, it is absolutely impossible to ensure every address being correct in a large work of this kind, because of the constant moving of many members of the profession, but so far as we have been able to test the addresses they are exceedingly "up to date." The method of testing the accuracy of a directory is very simple. Most business firms at times send circulars, or catalogues, or price-lists to the members of the industry, and the accuracy of the directory is gauged by the numbers returned through the post. We venture to say that no other directory approaches this in extent or accuracy, nor is better arranged for finding out the name required.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 545.)

In all these experiments the action was intensified by augmenting the capacity at the end of the lead connected to the terminal. As a rule, it is not necessary to resort to such means, and would be quite unnecessary with still higher frequencies, but when it is desired, the bulb or tube can be easily adapted to the purpose. In Fig. 25, for example, an experimental bulb, L, is shown, which is provided with a neck, *n*, on the top for the application of an external tinfoil coating, which may be connected to a body of larger surface. Such a lamp as illustrated in Fig. 25 may also be lighted by connecting the tinfoil coating on the neck, *n*, to the terminal, and the leading-in wire, *w*, to an insulated plate. If the bulb stands in a socket upright, as shown in the cut, a shade of conducting material may be slipped in the neck, *n*, and the action thus magnified. A more perfected arrangement used in some of these bulbs is illustrated in Fig. 26. In this case the construction of the bulb is as shown and described before, when reference was made to Fig. 19. A zinc sheet, Z, with a tubular extension, T, is slipped over the metallic socket, S. The bulb hangs downwards from the terminal, *t*, the zinc sheet, Z, performing the double office of intensifier and reflector. The reflector is separated from the terminal, *t*, by an extension of the insulating plug, P. A similar disposition with a phosphorescent tube is illustrated in Fig. 27. The tube, T, is prepared from two short tubes of a different diameter, which are sealed on the ends. On the lower end is placed an outside conducting coating, C, which connects to the wire, *w*. The wire has a hook on the upper end for suspension, and passes through the centre of the inside tube, which is filled with some good and tightly-packed insulator. On the outside of the upper end of the tube, T, is another conducting coating, C_1, upon which is slipped a metallic reflector, Z, which should be separated by a thick insulation from the end of wire, *w*.

The economical use of such a reflector or intensifier would require that all energy supplied to an air condenser should be recoverable, or, in other words, that there should not be any losses, neither in the gaseous medium nor through its action elsewhere. This is far from being so, but, fortunately, the losses may be reduced to anything desired. A few remarks are necessary on this subject, in order to make the experiences gathered in the course of these investigations perfectly clear. Suppose a small helix with many well-insulated turns, as in experiment Fig. 17, has one of its ends connected to one of the terminals of the induction coil, and the other to a metal plate, or, for the sake of simplicity, a sphere, insulated in space. When the coil is set to work, the potential of the sphere is alternated, and the small helix now behaves as though its free end were connected to the other terminal of the induction coil. If an iron rod be held within the small helix, it is quickly brought to a high temperature, indicating the passage of a strong current through the helix. How

FIG. 25.—Improved Experimental Bulb.

does the insulated sphere act in this case? It can be a condenser, storing and returning the energy supplied to it, or it can be a mere sink of energy, and the conditions of the experiment determine whether it is more one or the other. The sphere being charged to a high potential, it acts inductively upon the surrounding air, or whatever gaseous medium there might be. The molecules, or atoms, which are near the sphere are of course more attracted, and move through a greater distance than the farther ones. When the nearest molecules strike the sphere they are repelled, and collisions occur

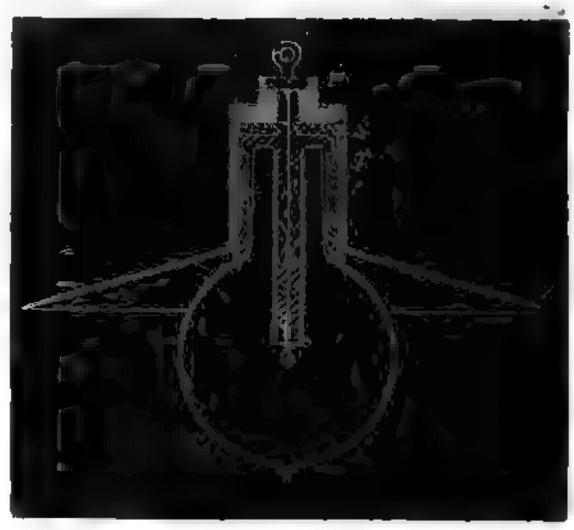

FIG. 26.—Improved Bulb with Intensifying Reflector.

at all distances within the inductive action of the sphere. It is now clear that, if the potential be steady, but little loss of energy can be caused in this way, for the molecules which are nearest to the sphere, having had an additional charge imparted to them by contact, are not attracted until they have parted, if not with all, so with most of the additional charge, which can be accomplished only after a great many collisions. From the fact that with a steady potential there is but little loss in dry air, one must come to such a conclusion. When the potential of the sphere, instead of being steady, is alternating, the conditions are entirely different. In this case a rhythmical bombardment

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

occurs, no matter whether the molecules after coming in contact with the sphere lose the imparted charge or not; what is more, if the charge is not lost, the impacts are only the more violent. Still, if the frequency of the impulses be very small, the loss caused by the impacts and collisions would not be serious unless the potential were excessive. But when extremely high frequencies and more or less high potentials are used, the loss may be very great. The total energy lost per unit of time is proportionate to the product of the number of impacts per second, or the frequency, and the energy lost in each impact. But the energy of an impact must be proportionate to the square of the electric density of the sphere, since the charge imparted to the molecule is proportionate to that density. I conclude from this that the total energy lost must be proportionate to the product of the frequency and the square of the electric density; but this law needs experimental confirmation. Assuming the preceding considerations to be true, then, by rapidly alternating the potential of a body immersed in an insulating gaseous medium, any amount of energy may be dissipated into space. Most of that energy, then, I believe, is not dissipated in the form of long ether waves, propagated to considerable distance, as is thought most generally, but is consumed—in the case of an insulated sphere, for example—in impact and collisional losses—that is, heat vibrations—on the surface and in the vicinity of the sphere. To reduce the dissipation, it is necessary to work with a small electric density—the smaller, the higher the frequency. But since, on the assumption before made, the loss is diminished with the square of the density, and since currents of very high frequencies involve considerable waste when transmitted through conductors, it follows that, on the whole, it is better to employ one wire than two. Therefore, if motors, lamps, or devices of any kind are perfected, capable of being advantageously operated by currents of extremely high frequency, economical reasons will make it advisable to use only one wire, especially if the distances are great.

FIG. 27.—Phosphorescent Tube with Intensifying Reflector.

When energy is absorbed in a condenser, the same behaves as though its capacity were increased. Absorption exists more or less always, but generally it is small and of no consequence as long as the frequencies are not very great. In using extremely high frequencies, and, necessarily, in such case also high potentials, the absorption—or what is here meant more particularly by this term, the loss of energy due to the presence of a gaseous medium—is an important factor to be considered, as the energy absorbed in the air condenser may be any fraction of the supplied energy. This would seem to make it very difficult to tell from the measured or computed capacity of an air condenser its actual capacity or vibration period, especially if the condenser is of very small surface and is charged to a very high potential. As many important results are dependent upon the correctness of the estimation of the vibration period, this subject demands the most careful scrutiny of other investigators. To reduce the probable error as much as possible in experiments of the kind alluded to, it is advisable to use spheres or plates of large surface, so as to make the density exceedingly small. Otherwise, when it is practicable, an oil condenser should be used in preference. In oil or other liquid dielectrics there are seemingly no such losses as in gaseous media. It being impossible to exclude entirely the gas in condensers with solid dielectrics, such condensers should be immersed in oil, for economical reasons if nothing else: they can then be strained to the utmost and will remain cool. In Leyden jars the loss due to air is comparatively small, as the tinfoil coatings are large, close together, and the charged surfaces not directly exposed; but when the potentials are very high, the loss may be more or less considerable at, or near, the upper edge of the foil, where the air is principally acted upon. If the jar be immersed in boiled-out oil, it will be capable of performing four times the amount of work which it can for any length of time when used in the ordinary way, and the loss will be inappreciable.

It should not be thought that the loss in heat in an air condenser is necessarily associated with the formation of visible streams or brushes. If a small electrode, enclosed in an unexhausted bulb, is connected to one of the terminals of the coil, streams can be seen to issue from the electrode, and the air in the bulb is heated; if, instead of a small electrode, a large sphere is enclosed in the bulb, no streams are observed, still the air is heated. Nor should it be thought that the temperature of an air condenser would give even an approximate idea of the loss in heat incurred, as in such case heat must be given off much more quickly since there is, in addition to the ordinary radiation, a very active carrying away of heat by independent carriers going on, and since not only the apparatus, but the air at some distance from it, is heated in consequence of the collisions which must occur. Owing to this, in experiments with such a coil, a rise of temperature can be distinctly observed only when the body connected to the coil is very small. But with apparatus on a large scale, even a body of considerable bulk would be heated, as, for instance, the body of a person; and I think that skilled physicians might make observations of utility in such experiments, which, if the apparatus were judiciously designed, would not present the slightest danger.

A question of some interest, principally to meteorologists, presents itself here. How does the earth behave? The earth is an air condenser, but is it a perfect or a very imperfect one—a mere sink of energy? There can be little doubt that to any small disturbance, as might be caused in an experiment, the earth behaves as an almost perfect condenser. But it might be different when its charge is set in vibration by some sudden disturbance occurring in the heavens. In such case, as before stated, probably

FIG. 28.—Lamp with Auxiliary Bulb, Confining Action to Centre.

only little of the energy of the vibrations set up would be lost into space in form of long ether radiations; but most of the energy, I think, would spend itself in molecular impacts and collisions, and pass off into space in the form of short heat, and possibly light, waves. As both the frequency of the vibration of the charge and the potential are in all probability excessive, the energy converted into heat may be considerable. Since the density must be unevenly distributed, either in consequence of the irregularity of the earth's surface, or on account of the condition of the atmosphere on various places, the effect produced would accordingly vary from place to place. Considerable variations in the temperature and pressure of the atmosphere may in this manner be caused at any point of the surface of the earth. The variations may be gradual or very sudden, according to the nature of the original disturbance, and may produce rain and storms, or locally modify the weather in any way.

From the remarks before made one may see what an important factor of loss the air in the neighbourhood of a charged surface becomes when the electric density is great and the frequency of the impulses excessive. But the action as explained implies that the air is insulating—that is, that it is composed of independent carriers immersed in an insulating medium. This is the case only when the air is at something like ordinary or greater, or at extremely small, pressure. When the air is slightly rarefied and conducting, then true conduction losses occur also. In such case, of course, considerable energy may be dissipated into space even with a steady potential, or with impulses of low frequency, if the density is very great. When the gas is at very low pressure, an electrode is heated more, because higher speeds can be reached. If the gas around the electrode is strongly compressed, the displacements, and consequently the speeds, are very small, and the heating is insignificant. But if in such case the frequency could

be sufficiently increased, the electrode would be brought to a high temperature as well as if the gas were at very low pressure; in fact, exhausting the bulb is only necessary because we cannot produce (and possibly not convey) currents of the required frequency.

Returning to the subject of electrode lamps, it is obviously of advantage in such a lamp to confine as much as possible the heat to the electrode by preventing the circulation of the gas in the bulb. If a very small bulb be taken, it would confine the heat better than a large one, but it might not be of sufficient capacity to be operated from the coil, or, if so, the glass might get too hot. A simple way to improve in this direction is to employ a globe of the required size, but to place a small bulb, the diameter of which is properly estimated, over the refractory button contained in the globe. This arrangement is illustrated in Fig. 28. The globe, L, has in this case a large neck, *n*, allowing the small bulb, *b*, to slip through. Otherwise the construction is the same as shown in Fig. 18, for example. The small bulb is conveniently supported upon the stem, *s*, carrying the refractory button, *m*. It is separated from the aluminium tube, *a*, by several layers of mica, M, in order to prevent the cracking of the neck by the rapid heating of the aluminium tube upon a sudden turning on of the current. The inside bulb should be as small as possible when it is desired to obtain light only by incandescence of the electrode. If it is desired to produce phosphorescence, the bulb should be larger, else it would be apt to get too hot, and the phosphorescence would cease. In this arrangement usually only the small bulb shows phosphorescence, as there is practically no bombardment against the outer globe. In some of these bulbs constructed as illustrated in Fig. 28, the small tube was coated with phosphorescent paint, and beautiful effects were obtained. Instead of taking the inside bulb large, in order to avoid undue heating, it answers the purpose to make the electrode, *m*, larger. In this case the bombardment is weakened by reason of the smaller electric density

FIG. 29.—Lamp with Independent Auxiliary Bulb.

Many bulbs were constructed on the plan illustrated in Fig. 29. Here a small bulb, *b*, containing the refractory button, *m*, upon being exhausted to a very high degree, was sealed in a large globe, L, which was then moderately exhausted and sealed off. The principal advantage of this construction was that it allowed to reach extremely high vacua, and, at the same time use a large bulb. It was found, in the course of experiences with bulbs such as illustrated in Fig. 29, that it was well to make the stem, *s*, near the seal at *e* very thick, and the leading-in wire, *w*, thin, as it occurred sometimes that the stem at *e* was heated and the bulb was cracked. Often the outer globe, L, was exhausted only just enough to allow the discharge to pass through, and the space between the bulbs appeared crimson, producing a curious effect. In some cases, when the exhaustion in globe, L, was very low, and the air good conducting, it was found necessary, in order to bring the button, *m*, to high incandescence, to place, preferably on the upper part of the neck of the globe, a tinfoil coating which was connected to an insulated body to the ground, or to the other terminal of the coil, as the highly-conducting air weakened the effect somewhat, probably by being acted upon inductively from the wire, *w*, where it entered the bulb at *e*. Another difficulty—which, however, is always present when the refractory button is mounted in a very small bulb—existed in the construction illustrated in Fig. 29—namely, the vacuum in the bulb, *b*, would be impaired in a comparatively short time. The chief idea in the two last-described constructions was to confine the heat to the central portion of the globe by preventing the exchange of air. An advantage is secured, but owing to the heating of the inside bulb, and slow evaporation of the glass, the vacuum is hard to maintain, even if the construction illustrated in Fig. 28 be chosen, in which both bulbs communicate.

But by far the better way—the ideal way—would be to reach sufficiently high frequencies. The higher the frequency the slower would be the exchange of the air, and I think that a frequency may be reached at which there would be no exchange whatever of the air molecules around the terminal. We would then produce a flame in which there would be no carrying away of material, and a queer flame it would be, for it would be rigid! With such high frequencies the inertia of the particles would come into play. As the brush, or flame, would gain rigidity in virtue of the inertia of the particles, the exchange of the latter would be prevented. This would necessarily occur, for, the number of impulses being augmented, the potential energy of each would diminish, so that finally only atomic vibrations could be set up, and the motion of translation through measurable space would cease. Thus an ordinary gas burner connected to a source of rapidly alternating potential might have its efficiency augmented to a certain limit, and this for two reasons—because of the additional vibration imparted, and because of a slowing down of the process of carrying off. But the renewal being rendered difficult, and renewal being necessary to maintain the burner, a continued increase of the frequency of the impulses, assuming they could be transmitted to and impressed upon the flame, would result in the "extinction" of the latter, meaning by this term only the cessation of the chemical process. I think, however, that in the case of an electrode immersed in a fluid insulating medium, and surrounded by independent carriers of electric charges, which can be acted upon inductively, a sufficiently high frequency of the impulses would probably result in a gravitation of the gas all around towards the electrode. For this it would be only necessary to assume that the independent bodies are irregularly shaped. They would then turn towards the electrode their side of the greatest electric density, and this would be a position in which the fluid resistance to approach would be smaller than that offered to the receding.

The general opinion, I do not doubt, is that it is out of question to reach any such frequencies as might—assuming some of the views before expressed to be true—produce any of the results which I have pointed out as mere possibilities. This may be so, but in the course of these investigations, from the observation of many phenomena I have gained the conviction that these frequencies would be much lower than one is apt to estimate at first. In a flame we set up light-vibrations by causing molecules, or atoms, to collide. But what is the ratio of the frequency of the collisions and that of the vibrations set up? Certainly it must be incomparably smaller than that of the knocks of the bell and the sound-vibrations, or that of the discharges and the oscillations of the condenser. We may cause the molecules of the gas to collide by the use of alternate electric impulses of high frequency, and so we may imitate the process in a flame; and from experiments with frequencies which we are now able to obtain, I think that the result is producible with impulses which are transmissible through a conductor. In connection with thoughts of a similar nature, it appeared to me of great interest to demonstrate the rigidity of a vibrating gaseous column. Although with such low frequencies as, say, 10,000 per second, which I was able to obtain without difficulty from a specially constructed alternator, the task looked discouraging at first, I made a series of experiments. The trials with air at ordinary pressure led to no result, but with air moderately rarefied I obtained what I think to be an unmistakable experimental evidence of the property sought for. As a result of this kind might lead able investigators to conclusions of importance, I will describe one of the experiments performed. It is well known that when a tube is slightly exhausted the discharge may be passed through it in form of a thin luminous thread. When produced with currents of low frequency, obtained from a coil operated as usual, this thread is inert. If a magnet be approached to it, the part near the same is attracted or repelled, according to the direction of the lines of force of the magnet. It occurred to me that if such a thread would be produced with currents of very high frequency, it should be more or less rigid, and as it was visible it could be easily studied. Accordingly, I prepared a tube about 1in. in diameter and one metre long, with outside coating at each end. The tube was exhausted to a point at which by a little working the thread discharge could be obtained. It must be remarked here that the general aspect of the tube, and the degree of exhaustion, are quite different than when ordinary low-frequency currents are used. As it was found preferable to work with one terminal, the tube prepared was suspended from the end of a wire connected to the terminal, the tinfoil coating being connected to the wire, and to the lower coating sometimes a small insulated plate was attached. When the thread was formed it extended through the upper part of the tube and lost itself in the lower end. If it possessed rigidity it resembled, not exactly an elastic cord stretched tight between two supports, but a cord suspended from a height with a small weight attached on the end. When the finger or a magnet was approached to the upper end of the luminous thread, it could be brought locally out of position by electrostatic or magnetic action, and when the disturbing object was very quickly removed an analogous result was produced, as though a suspended cord would be displaced and quickly released near the point of suspension. In doing this the luminous thread was set in vibration, and two very sharply marked nodes, and a third indistinct one, were formed. The vibration, once set up, continued for fully eight minutes, dying gradually out. The speed of the vibration often varied perceptibly, and it could be observed that the electrostatic attraction of the glass affected the vibrating thread; but it was clear that the electrostatic action was not the cause of the vibration, for the thread was most generally stationary, and could always be set in vibration by passing the finger quickly near the upper part of the tube. With a magnet the thread could be split in two and both

parts vibrated. By approaching the hand to the lower coating of the tube, or insulated plate, if attached, the vibration was quickened; also, as far as I could see, by raising the potential or frequency. Thus, either increasing the frequency or passing a stronger discharge of the same frequency corresponded to a tightening of the cord. I did not obtain any experimental evidence with condenser discharges. A luminous band excited in a bulb by repeated discharges of a Leyden jar must possess rigidity, and if deformed and suddenly released should vibrate. But probably the amount of vibrating matter is so small that in spite of the extreme speed the inertia cannot prominently assert itself. Besides, the observation in such a case is rendered extremely difficult on account of the fundamental vibration

The demonstration of the fact—which still needs better experimental confirmation—that a vibrating gaseous column possesses rigidity, might greatly modify the views of thinkers. When with low frequencies and insignificant potentials indications of that property may be noted, how must a gaseous medium behave under the influence of enormous electrostatic stresses which may be active in the interstellar space, and which may alternate with inconceivable rapidity? The existence of such an electrostatic, rhythmically throbbing force—of a vibrating electrostatic field—would show a possible way how solids might have formed from the ultra-gaseous uterus, and how transverse and all kinds of vibrations may be transmitted through a gaseous medium filling all space. Then ether might be a true fluid, devoid of rigidity, and at rest, it being merely necessary as a connecting link to enable interaction. What determines the rigidity of a body? It must be the speed and the amount of moving matter.

FIG. 30.—Apparatus Used for Obtaining High Degrees of Exhaustion.

In a gas the speed may be considerable, but the density is exceedingly small: in a liquid the speed would be likely to be small, though the density may be considerable; and in both cases the inertia resistance offered to displacement is practically *nil*. But place a gaseous (or liquid) column in an intense, rapidly-alternating electrostatic field, set the particles vibrating with enormous speeds, then the inertia resistance asserts itself. A body might move with more or less freedom through the vibrating mass, but as a whole it would be rigid.

There is a subject which I must mention in connection with these experiments: it is that of high vacua. This is a subject the study of which is not only interesting, but useful, for it may lead to results of great practical importance. In commercial apparatus, such as incandescent lamps, operated from ordinary systems of distribution, a much higher vacuum than presently obtained would not secure a very great advantage. In such a case the work is performed on the filament and the gas is little concerned; the improvement, therefore, would be but trifling. But when we begin to use very high frequencies and potentials, the action of the gas becomes all-important, and the degree of exhaustion materially modifies the results. As long as ordinary coils, even very large ones, were used, the study of the subject was limited, because just at a point when it became most interesting it had to be interrupted on account of the "non-striking" vacuum being reached. But presently we are able to obtain from a small disruptive discharge coil potentials much higher than even the largest coil was capable of giving, and, what is more, we can make the potential alternate with great rapidity. Both of these results enable us now to pass a luminous discharge through most any vacua obtainable, and the field of our investigations is greatly extended. Think we as we may of all the possible directions to develop a practical illuminant, the line of high vacua seems to be the most promising at present. But to reach extreme vacua the appliances must be much more improved, and ultimate perfection will not be attained until we shall have discarded the mechanical and perfected an electrical vacuum pump. Molecules and atoms can be thrown out of a bulb under the action of an enormous potential; this will be the principle of the vacuum pump of the future. For the present we must secure the best results we can with mechanical appliances. In this respect it might not be out of the way to say a few words about the method of, and apparatus for, producing excessively high degrees of exhaustion, of which I have availed myself in the course of these investigations. It is very probable that other experimenters have used similar arrangements; but as it is possible that there may be an item of interest in their description, a few remarks which will render this investigation more complete might be permitted. The apparatus is illustrated in a drawing show in Fig 30. S represents a Sprengel pump, which has been specially constructed to better suit the work required. The stop-cock which is usually employed has been omitted, and instead of it a hollow stopper, *s*, has been fitted in the neck of the reservoir, R. This stopper has a small hole, *h*, through which the mercury descends; the size of the outlet, *o*, being properly determined with respect to the section of the fall tube, *t*, which is sealed to the reservoir instead of being connected to it in the usual manner. This arrangement overcomes the imperfections and troubles which often arise from the use of the stop-cock on the reservoir and the connection of the latter with the fall tube. The pump is connected through a U-shaped tube, *t*, to a very large reservoir, R_1. Especial care was taken in fitting the grinding surfaces of the stoppers, p and p_1, and both of these and the mercury caps above them were made exceptionally long. After the U-shaped tube was fitted and put in place, it was heated, so as to soften and take off the strain resulting from imperfect fitting. The U-shaped tube was provided with a stop-cock, C, and two ground connections, g and g_1—one for a small bulb, *b*, usually containing caustic potash, and the other for the receiver, *r*, to be exhausted. The reservoir R_1 was connected by means of a rubber tube to a slightly larger reservoir, R_2, each of the two reservoirs being provided with a stop-cock, C_1 and C_2, respectively. The reservoir R_2 could be raised and lowered by a wheel and rack, and the range of its motion was so determined that when it was filled with mercury and the stop-cock C_2 closed, so as to form a Torricellian vacuum in it when raised, it could be lifted so high that the mercury in reservoir R_1 would stand a little above stop-cock C_1; and when this stop-cock was closed and the reservoir R_2 descended, so as to form a Torricellian vacuum in reservoir R_1, it could be lowered so far as to completely empty the latter, the mercury filling the reservoir R_2 up to a little above stop-cock C_2. The capacity of the pump and of the connections was taken as small as possible relatively to the volume of reservoir R_1, since, of course, the degree of exhaustion depended upon the ratio of these quantities.

With this apparatus I combined the usual means indicated by former experimenters for the production of very high vacua. In most of the experiments it was convenient to use caustic potash. I may venture to say, in regard to its use, that much time is saved and a more perfect action of the pump ensured by fusing and boiling the potash as soon as, or even before, the pump settles down. If this course is not followed, the sticks, as ordinarily employed, may give moisture off at a certain very low rate, and the pump may work for many hours without reaching a very high vacuum. The potash was heated either by a spirit lamp, or by passing a discharge through it, or by passing a current through a wire contained in it. The advantage in the latter case was that the heating could be more rapidly repeated. Generally the process of exhaustion was the following: At the start, the stop-cocks, C and C_1, being open, and all other connections closed, the reservoir R_2 was raised so far that the mercury filled the reservoir R_1, and a part of the narrow connecting U-shaped tube. When the pump was set to work the mercury would, of course, quickly rise in the tube, and reservoir R_2 was lowered, the experimenter keeping the mercury at about the same level. The reservoir R_2 was balanced by a long spring which facilitated the operation, and the friction of the parts was generally sufficient to keep it almost in any position. When the Sprengel pump had done its work, the reservoir R_2 was further lowered and the mercury descended in R_1 and filled R_2, whereupon stop-cock C_2 was closed. The air adhering to the walls of R_1 and that absorbed by the mercury was carried off, and to free the mercury of all air the reservoir R_2 was for a long time worked up and down. During this process some air, which would gather below stop-cock C_2, was expelled from R_2 by lowering it far enough and opening the stop-cock, closing the latter again before raising the reservoir. When all the air had been expelled from the mercury, and no air would gather in R_2 when it was lowered, the caustic potash was resorted to. The reservoir R_2 was now again raised until the mercury in R_1 stood above stop-cock C_1. The caustic potash was fused and boiled, and the moisture partly carried off by the pump and partly reabsorbed; and this process of heating and cooling was repeated many times, and each time, upon the moisture being absorbed or carried off, the reservoir R_2 was for a long time raised and lowered. In this manner all the moisture was carried off from the mercury, and both the reservoirs were in proper condition to be used. The reservoir R_2 was then again raised to the top, and the pump was kept working for a long time.

(To be continued.)

ELECTRO-METALLURGY.*

BY JOSEPH WILSON SWAN, M.A.

This is not the first time a lecture has been delivered here on electro-metallurgy. I find that so long ago as January, 1841, there was a lecture on the subject by Mr. Brand. At that time electro-metallurgy was very new and very small. It consisted solely of electroplating and electrotype. Electroplating had already begun to be practised as a regular industry, but it was still a question whether the new kind of plating was good, and there were not a few silversmiths who would not offer electroplate for sale because of its supposed inferiority to plate of the old style. That question has long been definitely settled by the fact that every week more than a ton of silver is deposited in the form of electroplate. Electrotype in 1841 was not so far advanced—it had not then been taken hold of by the artisan and manufacturer: it was still in the hands of the amateur. Looking at the matter after the event, it seems as though electrotype ought to have been discovered at least two years earlier than it was, for Daniell's battery was discovered in 1836, and it appears, from an after-the-event point of view, that from that moment electrotype was a perfectly obvious thing. But there it lay, for more than two years, a palpable streak of gold in a vein that, crossing the beaten track, and that had been washed bare by recent rains, the wonder is it was not observed and worked by some of the earlier passers-by.

In the same year that Daniell's battery was discovered (in 1836) De la Rue published the following observation: "The copper plate is also covered with a coating of metallic copper, which is continually being deposited; and so perfect is the sheet of copper thus formed, that, being stripped off, it has the counterpart of every scratch of the plate on which it is deposited." De la Rue had struck the vein, had recognised that it contained precious metal, but did not work it. Two years later Jacobi, Spencer, and Jordan came upon it at different points, saw its value, and each in his own way commenced the working that eventually became productive of much more than electrotype.

A similar tardiness in the utilisation of a previous discovery occurred in the case of electroplating and electro-gilding, for as early as 1805 Brugnatelli published the fact that he had succeeded in perfectly gilding two silver medals by means of the electric current. But it was not till 1841 that Elkington took out letters patent for the general application of this principle. While the Voltaic battery was the cheapest source of electric current, electro-metallurgy was necessarily restricted to artistic metal work, or to those applications where the fine quality of the electrotype cast outweighed the consideration of its cost, or where only a thin film of metal was required for the protection of a baser metal from the action of the air. Within this limited field, the electro-deposition of copper, of gold, of silver, of iron, and of nickel, has been carried on commercially with very great success and advantage for almost the whole period of the existence of the art. But beyond these bounds, set by the limitation of cost, it could not pass.

Now all this is changed—since engineer and electrician have united their efforts to push to the utmost the practical effect of Faraday's great discovery of the principle of generating electric currents by motive power. The outcome is the modern dynamo, with its result—cheap electricity. The same cause that has led to electric lighting, and to the electric transmission of power, has also led to a very great development of electro-metallurgic industry, and not only in the old directions but in new. It is no longer a matter of depositing ounces or pounds of metal, but of tons and thousands of tons. And it is no longer with metal deposition merely that electro-metallurgy now deals, but also with the extraction of metal from their ores, and the fusion and welding of metals. Electro-metallurgy has, in fact, so grown that now it is impossible to treat it in a complete manner in a single hour.

One of the latest developments is electric welding. This, in one of its forms—that invented by Elihu Thomson—has recently been so thoroughly explained and demonstrated by Sir Frederick Bramwell, that it is not necessary for me to do more than mention it as belonging to the subject. There is also another species of electric welding—that of Dr. Benardos, in which the electric arc is used, after the manner of a blow-pipe flame, to obtain the welding of such forms and thicknesses of iron, steel, and other metals as would be difficult or impossible to weld in any other way; and not only is the electric blow-pipe used for welding, but also for the repair of defects in steel and iron castings by the fusion of pieces of metal of the same kind as the casting into the faulty place, so as to make it completely sound. This new kind of electric welding as improved by Mr. Howard is now of sufficient importance to entitle it to the full occupation of an evening. I therefore propose to leave it for detailed description to some other lecturer, and content myself with calling your attention to the interesting collection of specimens on the table and in the library (lent by Messrs. Lloyd and Lloyd) showing the results of this process. Even with this curtailment, the extent of the field is still too great, and I must reduce it further by omitting a considerable section of that portion which relates to the extraction of metals from their ores, and in this connection only speak of the extraction of aluminium.

But, in the first place, I am going to speak of the deposition of copper, and you will pardon me if I treat it as if you were unacquainted with the subject. One of the wonderful things about the electro-deposition of copper, and, in fact, any other metal deposited from a solution of its salt in water, is that bright, hard, solid metal, such as we are accustomed to see produced by means of fusion, can by the action of the electric current be made to separate from a liquid which has no appearance of metal about it. The beginning of every electro-deposition process is the making a solution of the metal to be deposited. I am going to dissolve a piece of copper, the most elementary of all chemical operations, but I want to make it quite clear where the metal to be deposited comes from, to show that it is actually in the solution, and actually comes out of it again, for that is an effect so surprising that it requires both imagination and demonstration to make it evident. [*Experiment.*] There is projected on the screen a glass cell containing nitric acid. Mr. Lennox will put into it a piece of copper. He has done so. It quickly disappears, and a blue solution of copper nitrate is formed. Now, if I pass an electric current through this solution, or through some solution of the same kind, which, to save time, has been prepared beforehand, and immerse in it, a little apart from each other—the positive and negative wires coming from some generator of electric current—this will happen: metallic copper will come out of the solution, and attach itself as a coating to the negative wire, and consequently that wire will grow in thickness. At the other wire—the positive—exactly the reverse action will take place. There, if the positive wire be copper, it will gradually dissolve and become thinner. The quantity of metal deposited on the negative wire will almost exactly equal the quantity dissolved from the positive, and therefore the solution will contain the same quantity of metal at the end of the experiment as at first, but it will not be the same metal; it will be fresh metal dissolved from the positive wire, and the metal originally contained in the solution will have been deposited as metallic copper. [*Experiment.*] I will show on the screen this process in operation. Here are the two wires I spoke of. The electric circuit, which includes these two wires, is so arranged that on its completion the thick wire will be the positive and the thin wire the negative. Now please complete the circuit. One wire (the positive) is carrying an electric current into the copper solution, and the other (the negative) is carrying the current away. The solution is conveying the current between the wires, and one of the incidents of the transport of current from wire to wire by the solution is electro-chemical decomposition, or electrolysis; and the result of that is, the deposition, out of the solution, of copper upon one wire, and the dissolving away, or entering into solution, of copper from the other. Now it can clearly be seen that the wire that was thick is now thin, and the wire that was thin is now thick.

Imagine the growing wire to be an electrotype mould, and that the deposit of copper which formed on the wire has spread over the surface, and formed a nearly uniform film, and that by continuing the process it has become thick, that deposit, stripped from the mould, would be an electrotype. Or imagine the negative wire to be a thin sheet of pure copper, and the positive wire to be a thick sheet of impure copper, and suppose the action carried on so far that the thin sheet has become thick, by the deposition of copper upon it from the solution, and the thick one thin, by its copper entering into solution, that case would represent the condition of things in electrolytic copper refining. Allow your imagination to take one more short flight, and suppose that this is not a solution of copper, but one of silver, and that the growing wire is a teapot to be silvered, and further suppose that the dissolving electrode is silver, and you will then understand the principle of electroplating. It requires very little explanation to make the ordinary arrangement of electrotyping intelligible. Here is a trough containing sulphate of copper solution. Here is a mould that through the kindness of Messrs. Elkington has been prepared for me. This is connected with the negative pole of a battery, and here is a plate of copper connected with the positive pole. When I immerse the mould in the solution at about 2in. from the copper plate—the electrical circuit is completed, and the same electrolytic action that the experiment illustrated will take place. Copper will be deposited on the mould, and will be dissolved in equal quantity from the copper plate, and the supply of copper in the solution will thus be kept up. As it will take a little time to obtain the result I wish to show, I will put this aside for 10 minutes or so, and proceed to speak of different applications of this principle of copper deposition.

For the reproduction of fine works of art in metal, electrotype is unapproachable. The extreme minuteness with which every touch of graver or modelling tool is copied by the deposited metal film, separates electrotype by a wide space from all other modes of casting. Even the Daguerreotype image is not too exquisitely fine for electrotype to copy it so perfectly, that the picture is almost as vivid in the cast as in the original. It is this quality that has given to electrotype a *rôle* which no other process can fill, and, so far, its practical utility is not greatly dependent of the cost of the current. This applies to all those most beautiful things here and in the library, lent by Messrs. Elkington and Mr. Best. These could all have been produced commercially even if there had been nothing better for the generation of the current than Smee's battery—a very good battery, by the way, for small operations in copper deposition. It gives a very low E.M.F., and that is a defect, but in copper deposition the half volt or so is generally sufficient to produce automatically the required current density. One of the uses of electrotype, not greatly affected by the cost of deposition, is that of the multiplication of printing surfaces. In these days of illustrated periodicals, electrotype has come more and more into use for making duplicate blocks from wood engravings, which would soon be worn out and useless if printed from direct. It is also employed to make casts from set-up type, to be used instead of ordinary stereotype casts, when long numbers of a book have to be printed; also as a means of copying engraved copper plates. Here are examples of all these

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uses of the electrotype process. The electro-blocks are lent by Messrs. Richardson and Co., and the copper plates by the Director-General of the Ordnance Survey Office, Southampton. The plates illustrate the method employed at Southampton in the Map Printing Department. The original plates are not printed from, except to take proofs. The published maps are all printed from electrotypes. Here is an original plate—here the matrix, or first electro, with, of course, all the lines raised, which are sunk in the original. The second electro is, like the original, an intaglio. Here is a print from it, and here one from the original plate. Practically they are indistinguishable from each other, and bear eloquent testimony to the wonderful power of electrotype to transmit an exceedingly faithful copy of such a surface.

Nickel has of late years come into extensive use for what is termed nickel-plating, as applied to polished steel and brass. Nickel not only has the advantage over silver of cheapness, but also in some circumstances of greater resistance to the action of the air.

Another metal usually deposited in the form of a coating is iron. The electrolytic deposit of iron is peculiarly hard, so much so that it is commonly, but erroneously, spoken of as steel-facing. The deposition of a film of iron upon engraved copper plates, as a means of preventing the wear incidental to their use in being printed from, has become almost universal. Valuable etchings, mezzo-tints, and photogravure plates are thus made to bear a thousand or more impressions without injury. By dissolving off the iron veil with weak acid when the first signs of wear appear on the surface of the plate, and recoating it with iron, an engraved copper plate is, for all practical purposes, everlasting. In this case, of course, the film of iron is extremely thin—one or two hundred-thousandths of an inch. But it is possible to produce any of the metals commonly used as coatings in a more massive form. Here, for example, is an iron rod ½in. in diameter entirely formed by electrolytic deposition. I am indebted to Mr. Roberts-Austen for being able to show this, and also for this other example of a solid deposit of iron, and for this beautiful specimen of electrolytic coating with iron. Here also are solid deposits of silver—this drinking-cup is a solid silver electro-deposit.

These are all departments of electro-metallurgy which would have maintained a perfectly healthy industrial existence and growth without the dynamo; but now I come to speak of a branch of the subject—electrolytic copper refining—which, without that source of cheap electricity, could not have existed. This is the most extensive of all the applications of electro-chemistry, and is rendering valuable assistance to electrical engineering by the improvement it has led to in the conductivity of copper wire. One of the results of this is seen in the raising of the commercial standard of electrical conductivity. Ten years ago, contracts for copper wire for telegraphy stipulated for a minimum conductivity of 95 per cent. of Matthiessen's standard of pure copper. Now, chiefly owing to electrolytic refining, a conductivity of 100 per cent. is demanded by the buyer, and conceded by the manufacturer.

To show the difference between the past and present state of things in relation to the commercial conductivity of copper, I am going to exhibit on the screen measurements of the resistance of six pieces of wire of equal length and equal cross-section—they have been drawn through the same draw-plate. Three of the pieces are new, and three are old. The three new pieces are made from electrolytic copper, and are representative of the present state of things. The three old pieces are taken from three well-known old submarine telegraph cables, and they show how very bad the copper was when it was first employed for telegraphic purposes, and how great has been the improvement. I will take No. 1 wire as the standard of comparison. It is a piece of the wire about to be supplied to the Post Office Telegraph Department for trunk telephone lines. It will show the very high standard of conductivity that has been reached in the copper of commerce. I am indebted for it, and for two out of three of the old cable wires, to Mr. Preece. No. 2 wire is made from electrolytic copper deposited in my own laboratory. No. 3 is also electrolytic copper, but such as is commercially produced in electrolytic copper refining. It has been supplied to me by Mr. Bolton, to whom I am also indebted for wire No. 6—a particularly interesting specimen: it is from the first transatlantic cable—the cable of 1858. No. 4 wire is from the Ostend cable of 1860, and No. 5 wire is from the old Dutch cable. These wires are so arranged that I can send a small and constant current partly through any one of them, and partly through a galvanometer. When this is done the result will be a deflection of the spot of light on the scale from the zero point to an extent corresponding to the resistance of the particular wire in the circuit. The worse the wire is the greater will be the deflection. We will begin with the Post Office sample first. I connect the galvanometer terminals to wire No. 1—you see there is a deflection of 10deg. I will now shift the contacts to wire No. 2—exactly the same length of wire is included—but now, you see, there is a deflection of slightly less than 10deg., showing that this wire has a little lower resistance than No. 1. The difference is very small—it may be 2 per cent., and 2 per cent less of it would be required to conduct as well as the No. 1 wire. The next is No. 3—this is Mr. Bolton's wire, and shows a resistance almost equal to the last. Nos. 1, 2, and 3 are, therefore, nearly alike, and have a degree of conductivity almost as high as it can possibly be.

Now we come to the three old wires. We will take No. 4—the Ostend cable. There, you see, is a great difference. Instead of the spot of light being on the 10th degree, it is upon the 11th. We will now try No. 5—the Dutch cable. That drives the index to 17. Now I change to No. 6—the old Atlantic cable—and we have a deflection of no less than 25deg. I suppose we may assume that this wire fairly represents the commercial conductivity of copper in 1858, for it is highly probable that for a work so important as the first Atlantic cable every care would be taken in the selection of the copper. The result of this experiment shows that the copper of that cable was extremely bad as a conductor—that, in fact, it is 150 per cent. worse than the best commercial copper of to-day. In other words, it shows that in point of electrical conductivity one ton of copper of to-day will go as far as 2½ tons of such copper as was used for the cable of 1858. The change is largely due to electrolytic copper refining.

The process of electrolytic copper refining is the same in principle as that which produced the thickening of one of the wires and the thinning of the other in my first experiment. To prepare the crude copper for the refining process it is cast into slabs; these form the anodes, and correspond to the wire which in my experiment became thin. The cathodes, corresponding to the wire which became thick, are formed of thin plates of pure copper. Here are plates such as are used in electrolytic copper refining works. They are portions of actual cathodes and anodes, and represent the state of things at the commencement and at the end of the depositing operation, an operation that takes several weeks to complete, and effect the great change these plates show. In copper-refining works, an immense number of these plates, each having six to ten square feet of superficial area, are operated upon together, in a great number of large wooden vats, containing sulphate of copper solution and a small proportion of sulphuric acid. Electric current from a dynamo, driven by a steam engine or water power, is conveyed, by massive copper conductors, to the vats, arranged in long lines of 50 or 100 or more in series. Thick copper bars connect adjoining vats, and provide a positive and negative bar for each vat. The plates hang from these, in the solution, opposite each other, 2in. or 3in. apart. During the process, the impure slabs dissolve, and at the same time pure copper is deposited out of the solution upon the thin plates. The deposition and dissolving go on slowly, in some cases very slowly, for a slow action takes less power, and gives purer copper than a more rapid one. The usual rate is from one to ten amperes per square foot of cathode surface. You will better realise what these rates of deposit mean, when I say that one ampere per square foot rate of deposition gives for each foot of cathode surface nearly 1oz. of copper in 24 hours, and a thickness of one-eight hundredth of an inch; and therefore the production of one ton of copper, at that rate, in 24 hours would require a cathode surface in the vats, in round numbers, of 36,000 square feet. At the higher rate of 10 amperes per square foot, which is used where coal is cheap, one-tenth of this area would be required.

The importance of the electrolytic copper refining industry, and the extent of the plant connected with it, may be inferred from the fact that, reckoning the united production of all the electrolytic copper works in the world, nearly one ton of copper is deposited every quarter of an hour. Very little power is required for copper deposition if the extent of the dissolving and depositing surfaces is large, relatively to the quantity of copper deposited in a given time. Some of the impurities ordinarily found in crude copper are valuable. Silver and gold are common impurities, and these and some other impurities do not enter into solution, but fall down as black mud, are recovered, and go to diminish the cost of the process or increase the profit, and even those impurities which enter into solution are under ordinary conditions almost completely separated.

Electrolytic copper refining is both an economical and an effective process. The deposited copper is exceptionally pure. At one time it was supposed that it must necessarily be quite pure, but this is not the case; other metals can be deposited with the copper, but it is not difficult to realise in practice a close approximation to absolute purity in the deposited copper. Here is an example of the deposition of a mixed metal—brass—that is, copper and zinc deposited together, and there are in the library a number of interesting specimens of mixed metal deposition. These deposits of brass and other alloys show that more than one metal can be deposited at the same time. The great enemy to conductivity in copper is arsenic, and the deposition of arsenic as well as copper is one of the things to be guarded against in electrolytic copper refining. Not only are the chemical characteristics of electrolytically-refined copper generally good, but its mechanical properties are largely controllable. Usually, electrolytic copper is melted down and cast into billets of the form required for rolling and wire drawing. This treatment not only involves cost, but the copper is apt to imbibe impurity during fusion, though if the process is carefully conducted the deterioration is slight. But it is evident that the remelting of the deposited copper is a thing to be avoided if possible, and the question naturally arises why, now that deposition costs so little, may not the beautiful principle which comes into play in electrotype, and which enables the most complicated forms to be faithfully copied, be taken advantage to give to plainer and heavier objects their ultimate form? There are several reasons why this idea is not more frequently acted upon. One is, that the process of electrolytic deposition is slow; another, that knowledge of the conditions necessary for obtaining a deposit having the required strength and other qualities is not very widespread. Moreover, in the electrolytic deposition of copper, and indeed of all metals, there is a strong tendency to roughness on the outside of the deposit, and to excrescent growths, the removal of which involve waste of labour and material. These tendencies can, to a very great extent, be counteracted by careful manipulation, and the use of suitable solutions, and they can also be counteracted by mechanical means. This has been done by Mr. Elmore. He remedies the faults I have mentioned by causing a burnisher of agate (arranged after the manner of the tool in a screw-cutting lathe) to press upon and traverse a revolving cylindrical surface on which the deposit is

taking place, and while it is immersed in the copper solution. The result is that it is kept smooth and bright to the end of the process. But the use of the burnisher is not the only means available for the production of a smooth deposit. It was observed in the early days of electroplating how great a change was effected in the character of the metal deposited by the presence of a very small quantity of certain impurities. It was found, for example, that an exceedingly minute dose of bisulphide of carbon, if put into a bath from which silver was being deposited, caused the deposit to change from dull to bright. I have lately had experience of a similar kind with nickel and with copper. I was working with a hot solution of nickel, and up to a certain point the deposit had the usual dead grey appearance. Suddenly, and without doing anything more than putting in a new cathode, I found the character of the deposit completely changed. Instead of the grey, tough, adherent deposit, there was produced a brittle specular deposit, which scaled off in brilliantly shining flakes of metal. I sought for the cause of this extraordinary change, and on a slight hint traced it to the accidental introduction into the solution of a minute quantity of glue By adding gelatine to a fresh nickel solution, I obtained the same peculiar bright and brittle deposit that had resulted from the accident. I then made a similar addition to a solution of copper, and when I hit the right quantity—an exceedingly minute one—bright copper, instead of dull, or crystalline, was deposited. Here are some specimens. These were deposited on a bright surface, and they are bright on both sides. Not only is the copper made bright under the conditions I have described, but if the proportion of the gelatine be carried to the utmost that is consistent with the production of a bright deposit, it becomes exceedingly hard and brittle. Beyond this point the deposit is partly bright and partly dead, the arrangement of the patches of dead and bright being in some cases very peculiar, and suggestive of a strong conflict of opposing forces.

Before I leave the subject of copper deposition, I may mention that I have found the range of current density within which it is possible to obtain a deposit of reguline metal far wider than is commonly supposed. The rate of deposition in copper refining is usually very slow, and it is one of the drawbacks of the process, since slow deposition necessitates large plant. But rapid deposition necessitates a larger consumption of power, and larger cost on that account, and, therefore, there is a point beyond which it is not good economy to go in the direction of more rapid deposition. Still there are cases where, if we had the power to deposit more rapidly, it might be found useful to exercise it. The subject of more rapid deposition is also interesting from a scientific point of view. I therefore mention an unusual result I have arrived at in this direction. Taking, as one extreme, the slow rate of deposit, of one ampere per square foot of cathode—a rate not infrequent in copper refining—I have found that the limit in the other direction is not reached by a rate of deposit one thousand times faster. I have produced, and I hope to be able to produce before you, a perfectly good deposit of copper, with a current density of 1,000 amperes per square foot of cathode. [*Experiment.*] This cell contains a solution of copper nitrate with a small proportion of ammonium chloride. The plate on which I am going to produce a deposit of copper has an exposed surface of 21 square inches. Opposite, at a distance of 1in., is a plate of copper. When I close the circuit, a current of 140 amperes is passing through the solution. I continue this for just one minute. Now I wash it, and remove the outer edge so as to detach the deposit, and, as you see, I have a sheet of good copper—an electrotype. To have produced a deposit of this thickness at the ordinary rate used in electrotyping operations would have occupied more than an hour. In this experiment an extreme degree of rapidity of deposition has been shown. I do not intend to suggest such a rate as of practical value, but it is at least interesting, as showing that the characteristic properties of copper are not less perfectly developed when the atoms of metal have been piled up one on the other at this extremely rapid rate than when there is slower aggregation. I think it probable that a rate of deposit intermediate between this rate and the usual one of about 10 amperes per square foot may frequently be useful, for no doubt the slowness of the rate of deposit has often prevented electrotype from being made use of, where, if the rate could have been increased 10 times, it might have been employed with advantage. Here are some thick plates, deposited at the rate of 100 amperes per square foot. They are as solid and as free from flaw as plates deposited 10 times more slowly.

I said that electrolytic copper refining owed its existence to the discovery and improvement of the dynamo, and that other electro-metallurgic industries had originated from the same cause. One of these industries is the electrolytic production of aluminium. When Deville produced aluminium by the action of sodium on aluminium chloride exaggerated expectations were entertained of the great part it was about to play in metallurgy. It was very soon found that aluminium had not all the virtues that its too sanguine friends had claimed for it; but that it had a great many most valuable properties, and, given a certain degree of cheapness, a number of useful applications could be found for it. Some of these are suggested and shown by the various articles made of aluminium, kindly lent by the Metal Reduction Syndicate, and metallurgical research is rapidly extending our knowledge of its importance in connection with the improvement of steel castings, and the production of bronzes and other alloys of extraordinary strength. The cost of the aluminium produced by Deville's process was too great to permit of its use on any large scale for these purposes. After Davy demonstrated, by the electrolytic extraction of potassium and sodium, the power of the electric current to break down the strong combination existing between the alkaline metals and oxygen, it seemed natural to expect that aluminium would also be reduced by the same means. But Davy did not succeed in producing any appreciable quantity of aluminium by the electrolytic method. Deville and Bunsen were more successful, but they did not possess the modern dynamo, that has made all the difference between the small experimental results they achieved and the industrial production of to-day, a production now so large that I suppose every day it amounts to at least one ton, and has resulted in a very great reduction of the price of the metal.

There are two electrolytic processes at work. One is the Hall process—employed at Pittsburg, and at Patricroft, Manchester—and now in experimental operation here. The other, the Herault process, worked at Neuhausen, is not greatly different from the Hall process—the shape of the furnace or crucible is different, and the composition of the bath yielding the aluminium may be different, but in all essentials these two processes are one and the same. They depend on the electrolysis of a fused bath, composed of cryolite, aluminium fluoride, fluorspar, and alumina. In the Hall process this mixture is contained in a carbon-lined iron crucible—the cathode in an electric circuit, and between which and the anode, a stick of carbon immersed in the fused bath, a difference of potential of 10 volts is maintained. In carrying out the process on a manufacturing scale, there are many of these sticks of carbon to each bath. Here in our experimental furnace there is only one. The heat developed by the passing of so large a current as we are using (180 amperes) through an electrolyte of but a few inches area in cross-section, is sufficient to melt and keep red hot the fluorides in which the alumina is dissolved. The electrolytic action results in the separation of aluminium from oxygen. The metal settles to the bottom of the pot, and is tapped or ladled out from time to time as it accumulates. The oxygen goes to the carbon cylinder, and burns it away at about the same rate as that at which aluminium is produced. It is only necessary to keep up the supply of alumina to enable the operation to be continued for a long time—I mean, of course, in addition to the keeping up of the current and the supply of carbon at the anode.

By far the greater part of the cost of aluminium obtained by electrolysis is the cost of motive power—20 horse-power hours are expended to produce 1lb. of aluminum. Therefore it is essential for the cheap production of aluminium to have cheap motive power. There is one feature about the Neuhausen production of aluminium which is very striking, and that is the generation of the electric current by means of water power derived from a portion of the Falls of the Rhine at Schaffhausen. The motive for making use of water power is economy. But apart from that, it is interesting to see water replacing coal, not only in the production of power, but also in the production of the heat required in a smelting furnace. Here is the Hall apparatus on a small scale. It is simply a carbon-lined iron crucible, and a thick stick of carbon. As already mentioned, the crucible is the cathode, the stick of carbon the anode. As the process takes time to get into full operation, it was commenced some hours ago, and at the rate at which it has been working, we should by now have produced several ounces of aluminium. In beginning the process, the charge has first to be melted. This is done by bringing the carbon stick into contact with the bottom of the crucible, so as to allow the current to pass from carbon to carbon to develop heat between the electrodes. The alumina compound, which, when melted, forms the bath, is added in powder little by little, and when sufficient is melted the carbon stick is raised out of contact with the bottom, and the electrolytic action then commences. I will now ask Mr. Sample to empty the crucible and let us see the result of the operation, and while he is doing so I take the opportunity of expressing my very sincere thanks for his having so kindly and so successfully carried out this most interesting demonstration of the latest and one of the most important of all the applications of electricity to metallurgical operations. Here is the result of our experiment. It is not very large, certainly, but it is quite enough for our purpose, which is to illustrate the principle of a newly-developed electro-metallurgical industry directly derived from discoveries made at the Royal Institution.

INSTITUTION OF ELECTRICAL ENGINEERS.

DISCUSSION ON MESSRS. HEAVISIDE AND JACKSON'S PAPER ON "ELECTRICAL DISTRIBUTION BY THE NEWCASTLE-ON-TYNE ELECTRIC SUPPLY COMPANY."

Sir David Salomons asked what system was employed in connecting up new customers.

Mr. Crompton said he would like additional information on this point—how was the energy metered from the station? It appeared in the paper that apparently the virtual volts were multiplied by the virtual amperes, and that he would hardly think was meant. The next point referred to an item put in for labour and superintendence, and there was a misprint in the paper regarding it. There was given the total cost of the service—and they had what it meant by the word "service" translated further down as 1·94 pence per unit, whereas in the table just below it was given as ·816 per unit. There was no mention of meter losses. The total losses at the station were 25 per cent. Did that include meter losses?

Mr. Heaviside said the new customers were added on Sundays, when the service was shut down for a short time. The energy was simply measured by multiplying the virtual amperes into virtual volts. As regarded the cost of service the total figures had been given, and the total losses shown include the meter losses.

Mr. Crompton congratulated the authors on their paper. It was

the first honest, straightforward paper brought forward on the subject of the cost of distribution on the alternating-current system. There was evidently a great mistake in the way in which the energy in the high-tension circuit was measured. What they had done was practically useless, and gave them no guide whatever. He had himself in his high-tension station been for a long time trying to get accurate data, but could not get accurate data of the kind to be satisfied with. It would have been very interesting to have known really. The authors claimed an efficiency of 75 per cent., and the losses were stated at 25 per cent. That was a very high efficiency when all losses were taken into consideration. After the electricity was generated they had the losses in the distribution, and then they had the losses in the meters, in the houses, and other unexplained losses, which were a very considerable percentage of the whole. He thought he was correct in stating that those losses amounted to 10 to 12 per cent. in most stations. It might be said to be the fault of the meters, or it might be other causes; but at all events, quite independent of the efficiency of distribution, there were unexplained losses to be dealt with, and which had to be dealt with when they were bringing the cost down to the cost per unit sold to the customer, which was done so very properly the authors of that paper. He thought that was the only way they could deal with that matter—the cost of the units sold. He did not propose to consider the whole of the figures, because it was unnecessary to do so. The station was a new one, and the repairs exceedingly small. The authors could not pretend themselves that the cost of repairs had come up to what it would be in a few years' time. And the general charges, rent, rates and taxes, law charges, etc., appeared to be exceedingly low, and they were to be congratulated upon that, but those conditions were not of universal application. What interested the members were such figures as were affected by the system employed—fuel, petty stores, water, labour etc.. Now, they had been at considerable pains to supply this information to enable comparison of the cost of coal with that in the figures published of London stations. He thought they might have saved themselves a great deal of trouble, as they had already given accurately the quantity of water used. They had taken the whole quantity of the water used, and deducted very properly 10 per cent. of that for water used for other purposes, leaving that evaporated for generating electricity. In order to make a fair comparison, he had done the same with accounts over a similar period of stations in London with which he was acquainted, and found whereas they used 107·5lb. per unit sold, London stations used 60lb., and that appeared to be the difference in the efficiency of the whole system as compared with the efficiency of the low-tension systems at present in use in London. The following figures were put on the board:

	Low pressure.	Newcastle.
Coal	8·2	14·6
Water	60	107·8

If that figure was taken and multiplied by the number of units, they got a total sum expended of £15. 16s. per week on wages, and if that was divided into three shifts, they had three leading hands at 45s. a week, three engine drivers at 35s., and three stokers at 25s., which left absolutely nothing for superintendence. These were lower figures than in London, where some superintendence was necessary—even if only 10s. a week. Those put together showed very fairly that the system used at Newcastle, when compared with the other, was considerably more expensive, and that was to be expected, because he believed, not only was the alternating machine not so efficient as the direct-current, but the systems employed were not so economical, and rope transmission was another source of loss. More than all, the alternating system was obliged to be worked for so many hours not fully loaded, which was a heavy cause of loss and want of efficiency, and he believed the difference between the two coal bills very fairly represented the difference of efficiency. He thought they must recognise that the alternating plant had not worked out cheaper than the direct-current plant. Whether it would do so in the future remained to be seen. The author spoke of the figure he furnished—84 per cent.—as that regularly obtained as the efficiency of the generating plant—that was to say, electrical horse-power—on the terminals of the dynamos divided by the indicated horse-power of the engines was the efficiency that could be regularly obtained in practice. He said that not only was that efficiency obtained, but he knew that Messrs. Siemens Bros. had obtained 87 per cent. He had some machinery made by contractors that was working at that high rate of efficiency, and the figures of April for a station were given. The pounds of water per unit sold were 58, not 60; the labour bill was ·8 instead of ·110; the waste bill was divided—for petty stores there was a decimal point and two 0's before they came to anything; the oil (only 36 gallons were employed) came out at considerably under one-tenth of a penny, so that in every way the figures were lower than those given there, showing that those figures were already greatly improved on in London. The only other point was the question of load factor. He did not quite understand how that was calculated. The burning hours, so far as he could make out, were 4·50, and about 45 per cent. of the lamps were on at a time. That would make the load factor 11·4, about what would be expected at Newcastle.

Mr. Albright said one thing came out very prominently from this paper. Not only was coal dirt cheap in Newcastle, but superintendence also was to be got for nothing. He noticed that whereas at Newcastle the unit was sold for 4½d., the lamps were taken as 30-watt lamps: if his figures were right, each 30-watt lamp in Newcastle yields the good revenue to the company of 8s. 3d. In London, the hardly-used consumer bemoaned his lot because he had to pay 8d. per unit, yet for a 33-watt lamp there was an average revenue to the company of 8s. 6d., as against 8s. 3d. It might not be 8s. 6d. in all cases. He believed the secretaries of the London companies would say it was under 10s. So, in spite of the enormously reduced cost of 4½d., the Newcastle consumer did not appear to save much on his total bill per annum.

Mr. W. H. Preece said the whole time the current had been supplied to the post office at Newcastle it had given the very greatest satisfaction. It was quite impossible for the light to behave steadier and better. He did not know whether it struck the audience as the paper was read that one of the most startling and one of the strangest parts of that paper was not the cost of working, but the capital expenditure. This amounted to about £50 per kilowatt; a capital expenditure of something like £2 per lamp, which was less than the capital expenditure in London on the mains alone of some low-pressure systems. Careful examination showed that the capital expenditure of low-pressure systems averaged from £5 to £6 per 8 c.p. lamp, whereas at Newcastle it came out at less than £2 to 30s. per lamp. That meant that in establishing a system over a place like Newcastle at one-third the capital expenditure, they could afford to work it at twice the cost, and even then find they had an ample margin to pay a very handsome dividend. Again, another feature connected with that system was the ability to extend it to great distances—the paper said to a distance of 2½ miles—and to accommodate scattered clients in different parts of a great district at an expenditure averaging less than £2 per lamp.

Sir David Salomons wished to point out one matter which applied to London in particular. Londoners might at once cry out: "In Newcastle people get the current for 4½d., while here we have to pay 7½d." That, added to the rental of transformers, was calculated at 8d. for the continuous current. He would point that fact out—not in the way of criticising the paper, but merely to state the fact—London people were paying less for their current than those in Newcastle. He was in favour of the continuous current, and disagreed with Mr. Preece that the alternating current was more steady than the direct. It would be most interesting eventually to have the figures of alternating and direct systems compared, and he thought the figures of the City of London would be of enormous interest. There were 8,000 or 9,000 lamps already, and before October there would be over 30,000, and after that time the figures would be sufficiently accurate and the engines sufficiently loaded to obtain results which would be of value, independently of some 400 or 500 arc lamps that would be running.

Mr. W. M. Mordey did not wish to occupy any time that evening. He wanted the low-pressure people to have plenty of rope. Really, it was a paper on which he had nothing to say except in commendation, agreeing with nearly everything done at Newcastle. One or two things arose in the discussion to which he would like to refer, partly because he saw the paper in its early stages. As to the method of measuring raised by Mr. Crompton, the volts had been multiplied by the amperes. That he knew was a dreadful sin. There ought to be a new commandment, "Thou shalt not multiply the volts by the amperes," but they could do it at Newcastle without being far wrong. Mr. Crompton could not do it at Chelmsford without being very far wrong indeed. The transformers were not the same in the two places. Mr. Crompton had a considerable proportion of open-circuit transformers, in which there was a large magnetising current, and in which there was a great disparity between the real watts supplied and the apparent watts supplied. But any slight difference there might be between the real and apparent watts at Newcastle was more than covered by the fact that the meter losses had been treated in the way they had been in the paper. Mr. Crompton had thrown down a challenge or made a statement that alternators were not as efficient as direct-current dynamos. He would undertake that the Brush Company should put one of their alternators at the Crystal Palace at the disposal of the Expert Committee as the jury, and put, not transformers or anything else, but a lot of incandescent lamps. They would run a 100-unit alternator direct on to those lamps, arranged in series for that purpose, and Mr. Crompton could run a 100-unit direct-current dynamo, either direct or in parallel, and they could see who would run the most lamps with a given power. That was a test which would put the matter at rest perfectly. It did not involve anything they could not understand. There were no cosines about it or anything else. They had merely to take the candle-power of the lamps and the number of them. A point in the paper which had been overlooked was the extremely small labour staff necessary to run the machinery. The authors said they had for three 200 h.p. sets only three working-men in the establishment—stoker, engine-driver, and assistant. That spoke volumes for the character of the plant, and it would be difficult to get a direct-current plant to give better results than that. Reference was made to parallel working in the station, and supplementing what had been said by the authors he stated they had made attempts to work in parallel, and agreed that it would be an advantage not to have to switch the circuits off, but run them all in parallel. The alternators could not be got out of step; the failure was not due to the fact that they would not keep in step. He would undertake to pull the coils out of the machine before they would get out of step. On the question of parallel working he would like to say that although there had been a good deal of discussion about it during the last two or three years, he would make no claim whatever to have invented parallel working. All alternators had a tendency to run in parallel, but the difference was this: one machine might require to exercise greater current than another. The whole thing might be set at rest on that point by a simple test. Let any machine be run up to speed, thrown into synchronism, and run as motors idle. The machine that would run best in parallel was the machine that would run with

the lowest current to drive them empty as motors. That would show that although all machines tended to run parallel, some run with a given synchronism less than others, and therefore their plant efficiency was less than others. The paper was a commercial paper, and it was fitter that the direct-current people should try to pick holes in the result.

Earl Russell did not think that Mr. Mordey ought to take advantage of the absence of Mr. Swinburne to suggest that there was no magnetising current in closed-circuit transformers. He would suggest that the magnetising current of an open circuit compared with a closed-circuit transformer was as 6 to 9.

Mr. Mordey had found, in testing, an open circuit gave from 20 to 30; but was in the habit of designing transformers to work with from 1 to 2 per cent.

Mr. John Richardson desired to say two or three words with regard to the engine performance alluded to. The total loss between the indicated horse-power at the engine and the electrical horse-power given out to the customers had to be accounted for in some way. The authors had quite honestly put down 27·5 per cent. to friction. Of course, that was an assumption. He would scarcely allow that so much friction was expended in the engines, excepting that sometimes and for a considerable time they were working with very low loads indeed. When the engines were working at their fair power, the percentage of friction would not be more than 15 at the outside. That would also account for the 27lb. of water. That was the result of a very long test taken over 12 months. If that test had been taken over a few hours when the engines were working at their maximum efficiency, it would be nearer 17lb. per horse-power unit than 27lb. As regarded the difference of speed, the engines were fitted with very sharp cut-off gear, and it was thought that there might be a difference between the speed of the various parts of the revolution. With very elaborate apparatus which Mr. Heaviside placed at his disposal he spent some hours trying to find out what differences there were between one part and another part of the revolution. There was no difference that could be detected with the finest electrical measurements. It might be possible sometimes to detect differences that were not detected then. About the cheap superintendence, he thought perhaps the authors would say that there was even some margin for that skilled superintendence which Mr Crompton found was got for nothing. But three men were in the station, two workmen only, and the whole of the machinery, it was fair to say, worked with so little trouble that highly-skilled and highly-paid men were not needed. Quite ordinary mechanics, at comparatively low wages, very soon attained the necessary knowledge to manage such very simple machinery, and there was a considerable margin left for that skilled attendance that lay so near the heart of Mr. Crompton.

Mr. A. W. Heaviside did not propose to reply *seriatim* upon all points raised. The details of the capital expenditure, on an installation of 20,000-c.p. lamps, and the cost worked out thus: On buildings the proportion worked out at 2s. 8d. per lamp installed, station plant 13s. 1d., switchboards 7d., pipes and boxes 4s. 7d., mains within these pipes and boxes 4s. 7d., losses—plant 4d., transformers 4s. 2d.

A vote of thanks to the authors for the paper was accorded by acclamation.

LEGAL INTELLIGENCE.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY v. BOURNEMOUTH AND DISTRICT ELECTRIC SUPPLY COMPANY.

Electric Lighting and Telephoning.

The case of the Western Counties and South Wales Telephone Company *v.* the Bournemouth and District Electric Supply Company again came before Mr. Justice Chitty, sitting in the Chancery Division of the High Court of Justice, last Friday.

Affidavits were read in support of the plaintiff's case, declaring that it was almost impossible to speak through the telephone wires and hear replies, owing to the buzzing noise proceeding from the wires of the electric light company.

For the defence **Mr. Byrne, Q.C.**, said his clients had done, and were doing, all they possibly could to alleviate the disturbance, which, he said, was not nearly so bad as the plaintiffs made out, and the speaking through the telephone exchange system was carried on with much greater ease than was the case with any of the London telephone systems.

The affidavit of **Dr. Silvanus P. Thompson** was then read, the effect of which was that he visited Bournemouth on May 23rd, staying at the Mont Dore Hotel, and listened through the plaintiff company's systems during the time when the electric light current of the defendant company was in operation, and he could not detect any disturbance worth naming or that interfered to any material degree with the operation of the plaintiff company's system. He spoke through the telephone exchange to the works of the defendant company in the Bourne Valley. There was a faint hum like that which could be heard in a sea-shell when placed close to the ear, which was doubtless caused by the defendants' wire. It was slightly louder on the line to Bourne Valley. There was a deal of cross-talking, and he heard a woman's voice, which caused more disturbance than the faint hum. There was a well-known crackling noise due to the plaintiff company's carbon transmitters, and there were occasional whirring sounds, due to the use of electric bells on other lines in the plaintiff company's system. Taken as a whole, his evidence went to show that talking could be carried on with perfect ease through the telephone, and that it was far superior to the exchange systems of London and Manchester. Whilst speaking from the hotel, he could say that there was nothing in the shape of an actual disturbance which could be complained of.

Other evidence was given to the same effect, and Mr. Bryne continued to argue his case; but was stopped by his Lordship, who suggested that it would be better if an uninterested party, who could be relied upon, and who was well experienced in electrical works, could be sent down to examine the telephone and make a report as to his opinion, and put it in an affidavit, the motion standing over until that was done.

Both parties agreed to this and the motion stood over, his Lordship remarking that with such a conflict of evidence, and in cases like the present, it was much the better course.

COMPANIES' REPORTS.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.

Directors: Charles Nash, Esq., J.P. (chairman); Mark Whitwill, Esq., J P. (deputy-chairman); Henry Fedden, Esq.; Thomas Pole, Esq.; Richard Cory, Esq., J.P., alderman; and J. Staats Forbes, Esq., and G. H. Robertson, Esq. (nominated by the National Telephone Company, Limited, under agreement). General manager and secretary: Henry F. Lewis.

Report of the Directors for the year ending December, 31, 1891, presented to the shareholders at the seventh annual ordinary general meeting of the Company, held at the Grand Hotel, Broad-street Bristol, on Wednesday, June 8, 1892.

The Directors herewith submit to the shareholders the statement of receipts and expenditure up to the end of last year. The capital expenditure for the year ending December 31, 1891, was £20,956. 14s. 3d., making a total of £185,366. 6s. 5d. to date. The gross revenue of the Company for the year 1891 was £52,224. 1s. 6d., against £46,860. 15s. for the year ending December 31, 1890. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond December 31, 1891, is £15,548. 7s. 11d., against £14,212. 19s. 1d. brought in from the previous year. The whole of the Company's plant has been fully maintained and, where required, renewed out of revenue. The Company have continued to substitute, at considerable expense a large amount of copper and bronze wire for iron, which has increased the efficiency and durability of the plant. The working expenses, including maintenance and all working charges for the year 1891, have been £16,685. 10s. 10d. against £13,775 18s. 1d. for the year ending 31st December, 1890.

	£	s.	d.
Balance of net revenue account	£11,236	17	4
Dividend of 6 per cent. on the paid-up preference share capital for the year ending 31st December, 1891	6,000	0	0
Balance for appropriation, as per statement at end of accounts	£5,236	17	4

The Directors recommend that a dividend at the rate of 1 per cent. be paid for the year on the ordinary shares, absorbing £2,811. 19s. 5d., leaving a balance of £2,424. 17s. 11d., from which will have to be deducted the amount which may be voted for the Directors' fees for the year 1891. The number of subscribers to the exchange system and of private line renters has further increased, and the progress made during the year is considered to be satisfactory. The respective totals at the close of the years 1890 and 1891 were as follows:

	Exchange.	Private.	Total.
December 31, 1891.........	3,268	803	4,071
December 31, 1890.........	2,875	712	3,587
Increase in 1891	393	91	484

The mileage of trunks and renters' wires is as follows:

Erected up to December 31, 1891	5,753 miles
,, ,, December 31, 1890	5,018 ,,
Increase representing new business during 1891	735

In addition to the above, 191 miles of wire have been renewed during the year. The Company has increased its trunk system, so that on December 31, 1891, it had 505 miles of trunk pole lines connecting towns with each other, carrying 2,383 miles of wire; against 470 miles of pole lines, carrying 2,182 miles of wire, at the corresponding date in the previous year. It is within the knowledge of many shareholders that for some time past a gradual process of amalgamating the provincial telephone companies with the National Telephone Company, Limited, has been in operation. It has been felt by your Directors that either an amalgamation must be effected between this Company and the National Company, or additional capital must be raised to meet the requirements of its important district, comprising the Western Counties and South Wales, for which the approval of the National Company would be necessary. After much discussion the former alternative has been adopted, and terms have been provisionally arranged for the consideration of the shareholders. A provisional agreement is now in course of preparation, which will be submitted to a special meeting of this Company with as little delay as possible. As soon as the provisional agreement has been finally settled, full information of the terms of the proposed sale will be afforded to every shareholder

by circular or otherwise. The Directors have pleasure in acknowledging the continued uniform courtesy of the permanent officials of the Post Office Department. Mr. Mark Whitwill and Mr. Thomas Pole retire, the former by rotation and the latter by ballot, but are eligible for re-election. Messrs. Hudson Smith, Briggs, and Co. retire, but are eligible for re-election.

CAPITAL.

	Authorised.	Issued.	Balance.
20,000 preference shares £5 each	£100,000	£100,000	—
300,000 ordinary shares £1 each	300,000	281,197	£18,803
Debentures	80,000	79,450*	550
	£480,000	£460,647	£19,353

*£22,000 issued on security for temporary loans for £20,000.

Dr. REVENUE ACCOUNT, DEC. 31, 1891.	£ s. d.	£ s. d.
General management, salaries, wages, rents, rates, taxes, and office expenses at head office and branches, stationery, printing, and depreciation of furniture		6,438 1 8
Law charges, auditors' fees, fire insurance, and officers' guarantee premiums		494 18 9
Post Office telegraph service at Cardiff, Newport, and Plymouth		190 0 0
Working expenses, maintenance and renewals of lines, repairs, wages, stores, etc.		9,562 10 5
Balance carried to net revenue account		14,455 9 4
		£31,141 0 2
Cr.		
Rentals brought forward from last account	14,212 19 0	
Rentals received and outstanding, including receipts at call offices	38,011 2 5	
	52,224 1 6	
Deduct proportion of rentals carried forward to next year's accounts for unexpired periods, £15,548. 7s. 11d.; royalties, £4,943. 5s. 11d.; instrument rental, £674	21,165 13 10	
		31,058 7 8
Transfer and registration fees		12 12 6
Profit on sale of instruments (estimated)		70 0 0
		£31,141 0 2

Dr. BALANCE-SHEET, DEC. 31, 1891.	£ s. d.	£ s. d.
Sundry creditors		9,579 3 7
Dividends unpaid		12 3 10
Proportion of rentals in respect of period extending beyond 31st December, 1891		15,548 7 11
Net revenue account for 1891, £11,236. 17s. 4d. Less preference interim dividend at 6 per cent. per annum for half-year ending 30th June, 1891	£3,000 0 0	
		8,236 17 4
Overdraft at bankers		261 2 11
Reserve account	2,200 0 0	
Less balance of Jersey expenditure written off	500 0 0	
		1,700 0 0
		£35,337 15 7
Cr.		£ s. d.
Capital account balance, as per statement		7,916 6 5
Stores, tools, etc.		6,760 0 1
Sundry debtors		9,195 13 2
Office furniture, fixtures, and fittings		1,824 14 10
Royalties, etc., paid in advance		1,594 8 2
Agency and trunk line establishment		2,507 13 11
Suspense revenue charges		5,349 11 3
Cash in hand at head office and branches		189 7 9
		£35,337 15 7

ELECTRIC AND GENERAL INVESTMENT COMPANY, LIMITED.

Directors: His Grace the Duke of Marlborough (chairman), the Right Hon. Lord Cloncurry, Jos. B. Braithwaite, jun., Esq., George Herring, Esq., B. H. Van Tromp, Esq., Emile Garcke, Esq. (managing director).

Report of Directors, submitted to the third ordinary general meeting of the shareholders held at Winchester House, Old Broad-street, London, E.C., on Thursday, June 9, 1892.

The Directors beg to submit the balance-sheet and profit and loss account for the year ended 31st May, 1892. The profit and loss account shows a gross profit on the transactions of the year of £34,379. 4s. 5d., and after deducting all standing charges there remains a net balance available for distribution of £28,863. 12s. 11d. An interim dividend has already been paid on the ordinary shares for the first six months of the year at the rate of 20 per cent. per annum, and the Directors now recommend the payment of a further dividend upon the ordinary shares at the rate of 30 per cent. per annum for the past six months, and a dividend on the founders' shares of £30 per share. This will leave a balance of £20,863. 12s. 11d., which the Directors recommend should be applied as follows: £20,000 to reserve; £726. 0s. 1d. for writing off the preliminary expenses; £137. 12s. 10d. balance to be carried forward in equal moieties on account of the ordinary shareholders and founders. The amended articles of association recommended by the Directors have been adopted at two extraordinary general meeting of shareholders, and approved by the holders of the founders' shares, and have been registered as the articles of association of the Company. The Directors have appointed as managing director, Mr. Emile Garcke, M.I.E.E., formerly managing director of the Brush Electrical Engineering Company. The directors who retire this year are Mr. George Herring and Mr. B. H. Van Tromp, who, being duly eligible, offer themselves for re-election. The auditors, Messrs. Rait and Kearton, also retire, and offer themselves for re-election. It is proposed to make the dividends payable on June 15.

Dr. BALANCE-SHEET AT 31ST MAY, 1892.		£ s. d.
Capital authorised— £200,000 in 39,900 ordinary shares of £5 each. and 100 founders' shares of £5 each.		
Capital subscribed— 20,000 ordinary shares. 100 founders' shares.		
Capital called up— £1 per share on 20,000 ordinary	£20,000 0 0	
£5 ,, ,, 100 founders'	500 0 0	
		20,500 0 0
Reserve fund (ordinary shares account)		133 5 5
ditto (founders' shares account)		133 5 4
Sundry creditors		6,585 19 1
Profit and loss account— Balance from 1891	16 10 9	
,, ,, 1892, as below	28,847 2 2	
	28,863 12 11	
Less interim dividend paid on ordinary shares	2,000 0 0	
		26,863 12 11
		£54,216 2 9
Cr.	£ s. d.	£ s. d.
Investments at cost	46,500 0 5	
Less security sold for delivery, 15th June	5,715 16 0	
		40,874 4 5
Preliminary expenses		726 0 1
Sundry debtors		6,364 13 1
Cash on deposit at bankers		5,000 0 0
Cash on current account at bankers		1,341 5 2
		£54,216 2 9

PROFIT AND LOSS ACCOUNT YEAR ENDED MAY 31, 1892.	
Dr.	£ s. d.
General charges, including Directors' fees, and additional remuneration as per articles of association, general expenses, legal charges, advertising and auditors' fee, etc.	5,532 2 3
Balance carried to balance-sheet	28,847 2 2
	£34,379 4 5
Cr.	£ s. d.
Interest, commissions, and sundry profits	34,379 4 5
	£34,379 4 5

NEW COMPANIES REGISTERED.

Johnson's Patents, Limited.—Registered by Addleshaw, Warburton, and Co., 7, New-court, Carey street, W.C., with a capital of £40,000 in £10 shares. Object: to carry into effect an agreement expressed to be made between R. Johnson of the one part, and this Company of the other part, generally to carry on in all their respective branches the businesses of millwrights, ironfounders, mechanical and electrical enginoers, etc. There shall be not less than three nor more than seven directors. The first are: H. Mallalieu, R. R. Buck, F. Mallalieu, R. Johnson, and E. R. Buck. Qualification, £500. Remuneration, £300 per annum, and 25 per cent. on the net profits after payment of 10 per cent. dividend.

BUSINESS NOTES.

West India and Panama Telegraph Company.—The receipts for the half-month ended May 31 were £3,229, againt £2,837.

Western and Brazilian Telegraph Company.—The receipts of this Company for the past week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £3,032.

City and South London Railway.—The receipts for the week ending June 5 were £782, against £775 for the same period of last year, or an increase of £7. The total receipts to date from January 1, 1892, show an increase of £1,272 as compared with last year.

Bath Electric Light Company, Limited.—This Company has been dissolved under Clause 7 (4) of the Companies Act, 1880

(43 Vict., ch. 19) by notice in the *London Gazette*, dated May 10, 1892. The Company was registered on March 21, 1889, with a capital of £25,000 in £10 shares.

Electric and General Investment.—At a meeting held on the 1st inst. the Board of this Company resolved to recommend the payment of a further dividend on the ordinary shares at the rate of 30 per cent. per annum. making, with the interim dividend of 10 per cent., a total of 25 per cent for the year, and a dividend of £30 on each founders' share.

New Firms.—Messrs. New and Mayne, recently with Messrs. A. B. Gill and Co., have just opened offices as electrical engineers at Palace-chambers, Westminster, with works at Woking, Surrey. The new firm are taking up general contract work and the manufacture of specialties in electrical fittings and instruments.—Mr. Leoline A. Edwards, formerly of the Brush and Electric Construction Companies, has opened an office at 19, Lawrence Pountney-lane, where he intends to carry on the business of a mechanical and electrical engineer.

Notting Hill Electric Lighting Company, Limited.—This Company, whose capital is £100,000, of which £70,020 has been subscribed and paid up in full, invite applications for the balance of £29,980 in the form of ordinary preference shares, bearing a preferential cumulative dividend at the rate of 6 per cent. per annum. In addition to this, the ordinary preference shares will be entitled, after the holders of the rest of the ordinary shares shall have been paid a dividend for the year at the rate of 6 per cent. per annum, to share *pari passu* with the ordinary shares in any dividend or bonus in excess of such 6 per cent. available for division. The object of this issue is to enable the Company to extend the system to other parts of its area, the first extension being into the Phillimore Estate.

Consolidated Telephone Company, Limited.—The report of this Company for the year ended March 31, 1892, shows a net profit of £7,188, which, with the amount carried forward from last year, leaves a balance of £8,904 for disposal, after making provision for doubtful debts. The Directors propose to deal with the amount available as follows—viz. : To pay a further dividend of £1 per cent. for the half-year on the ordinary shares, and £3 per cent. on the preference shares for the half-year, making, with the interim dividend paid in November last, £6 per cent. for the year on the preference shares and £3. 10s. for the year on the ordinary shares, writing off the sum of £617 for depreciation of plant, machinery, and furniture, also £63. 16s. 8d. from cost of new building, thus leaving a balance of £1,366 to carry forward. The falling off in the profit in manufacturing is owing to American, French, and German competition, the prices of manufactures having had to be reduced to meet the demand for cheap goods, while the heavy duties placed on the Company's instruments abroad have no doubt tended to reduce their sales in that direction.

PROVISIONAL PATENTS, 1892.

MAY 30.

10265 **Improvements in electrical measuring instruments.** William Edward Ayrton and Thomas Mather, Central Institution, Exhibition-road, London.

10270 **Improvements in automatic electric lighting and in the apparatus therefor.** Ernest Lower Berry and Frederick Harrison, Lyric-chambers, Haymarket, London.

10274 **Improvements in distribution of electricity from a central station.** Andrew Sweet, 2, Cathcart-hill, Junction-road, London.

MAY 31.

10303 **Improvements in electrical reciprocating tools.** William Price Carstarphen, jun., 52, Chancery-lane, London. (Complete specification.)

10334 **Improvements in dynamo-electric generators and motors.** Rankin Kennedy, Carntyne Electric Works, Shettleston, Glasgow.

10367 **Improvements in connections and terminals for electric and other wires and cables.** Hercules Sanche, Monument-chambers, King William-street, London. (Complete specification.)

10388 **Improvements in secondary batteries.** Edwin Freund and Lars Bristöl, 21, Cockspur-street, London.

JUNE 1.

10430 **An improvement in electrical insulating sheet.** Robert Wood, 2, New Bridge-street, Manchester. (Charles W. Jefferson and Rupert R. St. John, ——.)

10451 **An automatic switch for electric current transformers.** Richard Norman Lucas, Arthur James Mayne, and Anthony George New, 9, Bridge-street, Westminster, London.

10456 **Improvements in the manufacture of conducting wires for electricity.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Madame Veuve Hannetelle, née Hortense Chapius, France.)

10466 **An improved telephone combination.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London.

JUNE 2.

1 472 **Improvements in apparatus for electrical and magnetic measurements.** James Alfred Ewing, Langdale Lodge, Cambridge.

10477 **An improved cut-off for electrical purposes.** William Wilson Horn, 151, Strand, London. (James P. Wooley, Canada.)

10478 **Improvements in electric generators.** William Grierson, 99, Waterloo-street, Glasgow.

10484 **An improved method of regulation of the potential difference of electrical conductors.** Josiah Sayers, 49, Melbourne-street, Derby.

10520 **Improvements in and connected with electric batteries.** August Van Boeckxsel, 4, South-street, Finsbury, London.

10523 **Improvements in arc lamp standards and climbing poles.** Wilfrid L. Spence, The Elms, Seymour-grove, Manchester.

10524 **Electrical insulating sheet.** Arthur H. S. Dyer, 36, Chancery-lane, London.

JUNE 3.

10544 **The extra rapid telegraphic apparatus with inverted currents.** Gaspare Sacco, 14, Leicester-place, London.

10602 **Improvements in telephones.** Ambrose Myall, 21, Cockspur-street, London. (W. Stuart Harrison, China.)

10608 **Improvements in electrical accumulators.** Bernard Mervyn Drake, John Marshall Gorham, Walter Claude Johnson, and Samuel Edmund Phillips, 66, Victoria-street, London.

10609 **The protection of insulating material or cable, line and like electric wires to preserve the insulating material from atmospheric and other destructive media, and for preventing escape of sound vibrations from telephone wires.** William Speirs Simpson, 166, Fleet-street, London.

JUNE 4.

10632 **Improvements in electric switches** Carl Thomas Blanch Brain, Bell's-buildings, South John-street, Liverpool.

10651 **An improvement in ceiling roses (or fittings) for use with pendant electric light fittings.** Herbert Thomas Sully, 4, Tower-villas, George-lane, South Woodford, near London.

10683 **Apparatus for automatic calculation of electric, gas or water distribution.** Hugo Helberger, 18, Buckingham-street, Strand, London.

10690 **Improvements in anodes for use in electric cells for treating chlorides, fluorides, or other compounds and the like.** Thomas Parker and Alfred Edward Robinson, 47, Lincoln's-inn-fields, London.

10696 **An improved detector cover for electric push-knobs and the like.** Alexander Shiels, 159, Coldharbour-lane, Camberwell, London.

10706 **Improvements in effecting electric telegraphic communication, applicable especially for telegraphing to lighthouses, either floating or on rocks, at a distance from the shore, or for telegraphing to and from vessels.** Willoughby Statham Smith and William Puddicombe Granville, 24, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1879.

2402. **Electric lights, etc.** Edison. (Fifth edition.)
5127. **Electric lamps, etc.** Edison. (Fifth edition.)

1880.

18. **Electric lamps.** Swan. (Fourth edition.)
4933. **Electric lamps.** Swan. (Fourth edition.)

1891.

8784. **Telegraphic signals.** Evershed and Richards.
10083. **Electrical cut-out.** Keating.
11625. **Electrical connections.** Holmes.
11644. **Lighting trains by electricity.** Timmis.
11767. **Telephone switchboards.** Kingsbury.
12040. **Voltmeters.** Dykes and Hird.

1892.

4017. **Electric measuring instruments.** Lake. (Weston.)
5086. **Electric block signalling apparatus.** Hall.
6961. **Electrical switches.** Heil.
7044. **Dynamo-meters.** Wood.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5⅝
Metropolitan Electric Supply	—	7⅝
London Electric Supply	5	⅞
Swan United	3½	4¼
St. James'	—	8
National Telephone	5	4⅜
Electric Construction	10	6¼
Westminster Electric	—	6 1/16
Liverpool Electric Supply	5	5½
	3	3½

NOTES.

Cannes.—The Cannes electric lighting company is to be reconstructed.

Sunderland.—A new and handsome post office is to be erected in Sunderland with all recent improvements.

Book Received.—"Everybody's Pocket Cyclopædia of Things Worth Knowing," by Don Lemon (Saxon and Co., 6d.).

Fleetwood.—The Improvement Commissioners have decided not to purchase the electrical plant offered by the Preston Electric Lighting Company.

Chemical Society.—The Chemical Society's rooms will be closed on and after the 20th inst. to permit of alterations, the introduction of electric light, and redecorations.

Long-Distance Telephony.—Interesting experiments in telephony have just been carried out between Dunkerque and Marseilles, a distance of 1,200 kilometres, or about 750 miles.

Train Lighting.—Mr. C. E. Thipps, locomotive superintendent of the Madras Railway, is undertaking experiments in train lighting. It is thought oil gas will be preferred.

The Telephone in Russia.—The *Daily News* Moscow correspondent states that St. Petersburg and Moscow are to be connected by telephone this summer. The distance is 409 miles.

Reading.—It is understood that the Reading Electric Lighting Company will make a considerable move for the extension of the light shortly, when parliamentary powers are received.

Bromley. — The Electric Lighting Committee of the Bromley Local Board have under consideration an offer of a site in West-street, Bromley, for the erection of an electric lighting station.

French Electric Railway.—Boulogne-sur-Seine, the pretty suburb of Paris, is to have an electric installation for lighting, and there is also talk of an electric railway between it and Paris.

Transmission of Power. — The French Société d'Encouragement à l'Industrie has awarded a prize of 3,000f. to M. Hillairet, as author of the best project for transmission of natural forces.

Chiswick.—The Chiswick Local Board have rétained the services of Mr. Morgan Williams to advise them on the question of carrying out the electric lighting under the provisional order for the district.

Whitby.—The Highway Committee of Whitby has been requested to obtain terms for public lighting for the year, the clerk explaining that the enquiry did not include the consideration of electric light.

Theatre Lamps.—The Lithanode and General Electric Company (late the Mining and General Electric Lamp Company) are going to provide portable lamps for use in the summer ballet at the Crystal Palace.

Huddersfield.—Tenders are invited for lighting by arc and incandescent light the sewage works at Huddersfield. Particulars can be obtained from Mr. A. B. Mountain, the borough electrical engineer.

Bradford.—The tender of Messrs. Thornton and Creppin for providing and fixing the ironwork required in the extension of the works at the central station has been accepted. The amount of the contract is £1,132.

St. Helens.—At the meeting of the St. Helens Town Hall Committee on Tuesday, the surveyor reported that the fittings for the electric light were proceeding slowly, and he intended temporarily to light the assembly-room that night at Mr. Labouchere's meeting.

Guildford.—The Guildford Town Council are in a hurry to have definite information as to the electric lighting of the town, and seem to be in earnest in the matter, for they have written to their engineer saying that unless they had a report by next meeting they must take other proceedings.

Brazilian Cable.—News has been received of the successful laying of a duplicate cable by the Western and Brazilian Telegraph Company between Rio de Janeiro and the River Plate, thus completing the direct duplicated system of their telegraphs between this country, Brazil, Uruguay, and the Argentine Republic.

Electric Lighting in France.—Those interested in electric lighting installations in France will find a valuable and exhaustive list of central stations throughout that country, with map, in *L'Industrie Electrique* for June 10th. The list gives names of proprietors, date of starting, nature of lighting, kind of engines, horse-power, system of dynamo, nature of distribution of current.

Dublin.—Messrs. Woodhouse and Rawson United, Limited, inform us that they have recently opened a branch office, showroom, and stores at 16, Fleet-street, Dublin, their former agencies at Belfast and Cork being given up, and the whole of their Irish business concentrated in Dublin, under the management of Mr. Arthur H. M. Francis, to whom all communications should be addressed.

Edison and Thomson-Houston.—A special edition of the New York paper *Electricity* is promised shortly, devoted to the early history and subsequent development of the Edison and Thomson-Houston Companies up to the time of their amalgamation, with incidents and anecdotes of their principal men, and an account of the financial history of the companies. It should prove interesting reading.

Accumulator Patents.—The Société de l'Accumulateur Multitubulaire (Tommasi's patents) and the Popp Company have both applied for licenses to the Faure-Sellon-Volckmar Company for right to use salts and oxides of lead on payment of a royalty. At a time when Gadot, Tudor, and others are fighting the claims, this concession on the part of two companies is naturally looked upon as significant.

Clough Hall.—The electric installation at Clough Hall, in the Potteries, has been carried out by the Woodhouse and Rawson Kidsgrove Engineering Works, and was practically complete on Whit Monday. The installation was carried out with very great rapidity, and is remarkable from the fact that the entire plant has been manufactured by the Woodhouse and Rawson Company. The electrical work was superintended by Mr. Bertram Thomas, and the engineering work by Mr. John Henry Owen, assisted by Mr. Todd.

American Items. — The three drawbridges in Milwaukee are now worked by Thomson-Houston motors. The works of the Cliff Paper Company, at Niagara, are to run by Leppel turbines of 1,100 h.p. Electricity, in place of steam, is to be used on a standard gauge railway on the Beaver and Ellwood Railway, Pittsburgh. All telephone, telegraph, and electric light wires in Pittsburgh are to go underground within four years. A telephone cable has been laid from East Boston to Boston under the river at the South Ferry by the New England Telephone Company.

Portsmouth.—At a meeting of the Portsmouth Town Council on the 7th inst., the Electric Lighting Committee

reported that in their opinion it would be necessary to acquire the piece of land adjoining the site in Gunwharf-road, recently acquired by the Corporation, for an electric light station. This piece of land was at present let for £22 per annum, and it was understood that the term for which it was let had about two or three years to run, but as there was an opportunity now of buying the land, subject to this tenancy, at £600, they recommended that they be authorised to buy it. This was carried.

Royal Printing Works.—The Royal Printing Works at Vienna are extensively fitted with electric appliances. There is power to the extent of 300 h.p. employed, of which 100 h.p. is for electric light. There are 1,700 lamps of 10 c.p. and 16 c.p., 50 of 100 c.p., and 18 arcs. Besides this, the printing works has two electroplating establishments for manufacture of blocks for bank notes. The first uses a Krœtlinger dynamo of 2·5 volts and 80 amperes, and the other one of the same, and also a Schuckert machine of 4 volts and 230 amperes for depositing steel and nickel. Lastly, in a cellar is a complete photographic-room furnished with electric light.

Groth Patents.—The Grange Syndicate, Limited, which was incorporated for the purpose of experimenting and developing a patent process for tanning leather by electricity, is being wound up, operations having been suspended for want of funds, and the total deficiency amounts to £2,129. The failure is attributed chiefly to the inability of Mr. Groth, the patentee, to dispose of his foreign patents. So far as the experiments of tanning by electricity has proceeded, it is claimed that it has been a success, and that leather submitted to the process has turned out in a condition which, under better financial support, would have proved remunerative.

Whitehaven.—At the monthly meeting of the Whitehaven Town and Harbour Trust, held last week, the proposed electric lighting of the town was discussed. The chairman said the committee which had been appointed had visited Preston, where temporary plant had been laid down and permanent plant was now being erected. He thought it advisable that they should have the opinion of an electrical engineer before coming to a decision, and he proposed that the Board empower the Electric Lighting Committee to obtain the services of some engineer of this kind and consult him as to the lighting before committing themselves to any great expense. This proposal was carried.

Lyons.—At present there are used at Lyons 30,000 cubic metres of water a day, there are 130,000 jets of gas, and 13,000 h.p. of engine power. M. Verny in a recent project proposes to unite these great supplies in one by power transmitted electrically. He proposes to progress gradually, so that the first transmission of power could be made within eight months of the start. He proposes to transmit at first 2,500 h.p. a distance of 195 kilometres on the three-wire high-tension system at 40,000 volts, having a second additional set of wires for each 5,000 h.p. Sub-stations of 3,500 h.p. each would be erected eventually in six different parts of Lyons. Details of the estimate of cost are given in *L'Electricien* for June 11.

Coventry Tramways.—At last week's meeting of the Coventry County Council, the minutes of the General Works Committee contained the following: "Read letter of Mr. R. B. Johnson, solicitor to Mr. W. S. G. Baker, the intending purchaser of the undertaking of the tramways company, asking the Corporation to consent to an extension of the license for the use of steam for a further period of six months, from the 1st June next, to enable Mr. Baker to complete his purchase of the electric installation. Ordered that, without assenting to the proposed or any particular form of traction, the committee recommended the Council to consent to the proposed extension of the license on condition that the cars continue, as at present, to stop at the top of Bishop-street."

Electric Coal-Cutters.—We have had enquiries addressed to us as to who are manufacturers of electric coal-cutters. Messrs. W. S. Goolden and Co. have for some time manufactured coal-cutters driven by electric motors which have worked with considerable success. Their patents for coal-cutting machinery have lately, however, been purchased by the Woodfield Syndicate, of 1, Woodfield-road, Westbourne Park. Electric coal-cutters have also been made by the General Electric Traction and Power Company, and applied, along with electric pumping plant, in collieries in the North of England. In America the Thomson-Houston and the Westinghouse Company have done very considerable work with electric coal-cutters, and the Westinghouse Company have largely applied the Tesla alternating-current motor to this work, besides the ordinary motors.

Chatham.—In spite of the many difficulties which have been encountered, the directors of the Chatham, etc., Electric Lighting Company are confident that before long the light will be installed in many more places of business and private residences throughout the district. The new works in Whittaker-street, Chatham, have just been opened, and are found to be eminently suited for the requirements of the company. The new and powerful engine of 150 h.p., developing 50 amperes at 2,400 volts, gives every satisfaction. The company will shortly commence to lay their mains underground, as according to the terms of their provisional order they are bound to carry out this work by the end of August. Until this is done the company do not desire to increase the number of their customers, as it would simply mean a double expense in connection with the wires.

Iron for Dynamos.—The *Daily Chronicle* says: "The American electrical journals are complaining that, in spite of Mr. M'Kinley's heaven-born tariff, it is extremely difficult to obtain native manufactured iron suitable for electrical purposes, such as the construction of dynamo and motor armatures, transformers, etc. It is frequently badly and irregularly annealed and finished by rolling, scaling, and so forth. The result is that many of the instrument makers are forced to import English, Welsh, and Swedish iron, and pay high duties on it, in spite of Mr. Carnegie's comforting assurance that he and Mr. Hewett are really losers by the protection tariff. Pennsylvania iron, even of the best quality, will not suit their purpose—the Pittsburg smelters not understanding their business quite as well as the 'effete Europeans' over whose backwardness we sometimes see much sarcastic criticism."

New South Wales.—The central station for the borough of Redfern, Sydney, New South Wales, has been fitted with an alternate-current machine, manufactured by Messrs. Mather and Platt, of Salford. The dynamo is designed to give 120 amperes at 1,000 volts, running at 400 revolutions, the frequency being 80 per second. The following technical particulars are given: The resistance of the magnets is 16 ohms, and of the armature ·11 ohm, while the exciting current required is ·5 ampere. Hence the electrical efficiency at full load is 98·4 per cent., and still higher at half load: a better result than has ever been attained in continuous-current dynamos. Careful tests have been made on the commercial efficiency of a similar machine of somewhat smaller size, by driving it from a motor of known efficiency and absorbing the power generated by the alternator in a non-inductive water resistance. These tests show a commercial efficiency of 92 per cent.

Cheltenham.—At the monthly meeting of the Cheltenham Town Council last week Mr. Norman proposed the adoption of the minutes of the Electric Lighting Committee. According to these the town clerk had reported that Prof. Ayrton had accepted the proposals of the committee, in accordance with the terms of their resolution of 20th June, that he had since been down to Cheltenham, had inspected the localities proposed to be lighted and the suggested sites for the central station, had seen the chairman, the borough surveyor, and himself, and had suggested a practical experiment in the Promenade of the incandescent lighting; and that Prof. Ayrton had seen sent in an interim report. This had been laid before the committee. At a second meeting the subject had been further considered, and in accordance with Prof. Ayrton's suggestion that the committee should confer with him in town, when he would be able to show them the St. Pancras and other lighting systems, it was resolved that the committee should arrange an interview. Mr. Lawrence seconded the motion, which was agreed to.

Electric Launches on the River.—We notice that several improvements have lately been made in some of the electric launches now running on the river. The "Myionu,' Captain Homfray's favourite boat, has been fitted up with Epstein accumulators, and had a new "W & R" motor placed in her. This enables her to run at a much higher speed than formerly; with the exception of the "Metadel" she is said to be the fastest electric launch on the river. It is also found to be a great conveniense to be able to charge the accumulators at the rate of 50 amperes, as this enables the cells to be fully charged in about three hours instead of six, as formerly. A number of improvements have also been made in the "Pioneer," including the fitting up of a new motor. The steering gear has been carried forward to enable a neat cabin to be put over her. She is now being used by the officers of the 3rd Battalion Grenadier Guards at Windsor, and, thanks to the simplicity of the new patent single-lever switch fitted in her by her makers, Messrs. Woodhouse and Rawson, they are able to dispense with all assistance in working her.

Country Town Lighting.—A correspondent of the *Journal of Gas Lighting* criticises the balance-sheet of the electric light company of Fareham, which, he says, has earned £750, with an expenditure of £1,100. The company has been at work for only sixteen months, and has not yet achieved a profit, from which it is argued that electric light cannot be supplied in small country towns at anything like prices that could compare with those now paid for gas. There are two things to be kept in view in these discussions—one, that electric light is worth a good deal more than gas, and can usually obtain a higher price; and, second, the comparison depends a good deal upon the price of gas in the typical "small town." A difficulty has been "irregularities" for the first year's service, now happily surmounted. But it would be well to have the manager's or the directors' views upon the comparative cost of gas and electricity in Fareham—particulars which would be interesting to engineers projecting central installations for other small towns. In France, electric lighting in country towns has progressed very rapidly during the last two years, and there is no real reason why the same should not be the case in Great Britain. In Ireland, where the price of gas is higher, considerable success has been obtained.

Testing.—We have received the scale of fees from the Electrical Standardising, Testing, and Training Institution. This institution undertakes, besides college work, the testing of instruments and the inspection and certification of electrical installations. The standardising or calibration of instruments is carried out at 7s. 6d. per instrument, with a reduction per dozen or above; marking scales of new instruments is the same, while "standardising" meters, alternate or direct, including table of percentage errors and constant at load specified, is half a guinea, with reduction on a quantity; and experimenting and reporting on new meters can be done at a guinea. Further than this, large work is undertaken, and inspecting, testing, and reporting on plant up to £500 value is carried out at 2½ per cent., special terms above that amount, while inspection of house wiring can be obtained at half a guinea per 25 lamps. The institution also "contracts with local authorities to fulfil all the statutory obligations of inspectors under the Electric Lighting Acts"; it investigates and reports upon new inventions; and for inventors in the process of inventing there are private experimental rooms at 30s. a week, with current to be had at 1s. per 10 ampere-hours, an arrangement which is likely to be appreciated.

Perpetual Syphon.—Mr. Thomas Caink, engineer and surveyor, writing to us from Malvern Link with reference to the "perpetual syphon" patented by M. Berlin, claims that anyone is now at liberty to use such a syphon, as it was the subject of a patent taken out by him in 1884, which has since expired. The patent was for an automatic pressure-changing gas governor, in conjunction with which the syphon was employed. The following is the description given of the syphon part: "One of the legs of a syphon pipe which has the lower end of each leg turned upwards or otherwise 'sealed,' extends from the bottom of one of the chambers through the top of the holder; the other leg extends downwards, outside the gasholder tank, and terminates with its open end on a level with the open end of the other leg of the syphon. This arrangement enables the syphon, when once charged, to remain charged indefinitely, even though neither leg may be immersed in the water." Mr. Caink adds that in January, 1886, he provisionally protected a useful modification of this syphon in conjunction with an improved zinc-copper sulphate cell, for the purpose of drawing off the zinc-sulphate solution. Its form enables the lower and denser portion of the liquid to be removed by merely adding water to the upper portion until the solution is reduced to the required density.

High-Tension Experiments.—Mr. L. Pyke is exhibiting some interesting high-tension apparatus at the Society of Arts, shown in action at the *soirée* on Wednesday. The following is Mr. Pyke's description: It has hitherto not been possible to work any considerable number of vacuum tubes from one generating source, as a tension sufficiently high could not be obtained suitable for working a very large number in series. The nature of the discharge being disruptive, parallel working, as it is ordinarily understood, is not possible. In the present instance, however, the tubes are each connected with terminally-connected inductors, themselves counterpoised against two external conductors connected to the terminals of the transformer. By this means each tube takes a predetermined portion of the discharge, the discharge being governed by the size of the foil inductor, by their distance from the common inductor, and quality of the interposed dielectric. By this means beautiful effects can be obtained. The vacuum tubes are lit by a Pyke and Harris transformer, the E.M.F. employed being 100,000 volts, and the transformer is so arranged that the liquid insulation may have as much facility for circulating round and through same as is necessary to keep down the temperature, and again to cool the liquid insulator in its turn. The container is so arranged that it may offer sufficient surface for this purpose. The whole is maintained free from moisture by some substance

capable of decomposing same, situated in the circulating system.

High-Speed Electric Railway.—Dr. Wellington Adams has expounded to the New York Club his projects for a high-speed electric railway between St. Louis and Chicago for the World's Fair next year. The proposed line is 248 miles long. It will cost 6,000,000dols. to build, and if 10 per cent. of the expected 30 million visitors travel on the line a good profit would be assured. Two steam central stations would be placed along the line, and at Wilmington there is 10,000 h.p. in water power which can be used ; the line also passes over a coalfield. It is proposed to break the line in four sections of 50 or 60 miles, each with its generating station, and the syndicate, it is said, have already 60 per cent. of the right of way. The line will be absolutely straight, and the run is to be made, at 100 miles an hour, in 2½ hours. Dr. Adams thinks the railway will draw better than the Eiffel Tower did at Paris. They are now building one car and two trucks ; the driving wheels are 6ft. diameter; the motors will weigh 6,132lb., and will develop 200 h.p. at 500 revolutions. They expect to use the rotary-current multiplex system, generated at 500 volts and transformed up to 25,000 volts, and down again at sub-stations. The line will be divided into sections of 10 miles each, with transformer stations. Each motor will take 100 amperes picked up with broad contacts from suspended trolley wires. Electric brakes will be used. Mr. O. T. Crosby and Prof. Forbes were at the lecture, and Prof. Forbes was said to have been seen making calculations on his cuff, each of which was followed by a smile. Dr. Adams, however, seems in earnest.

Southampton Royal Pier.—The lighting of New Royal Pier, Southampton, opened by H.R.H. the Duke of Connaught, K.G., on Thursday, 2nd June, is accomplished throughout by the electric light, the current being supplied from the local supply company's station. The installation is divided into three circuits, each controlled by separate switches on the switchboard. The switchboard is placed in the cloakroom, and contains, besides the switches for the three circuits, two ammeters and one voltmeter and the usual fuse terminals for each circuit. The cables are carried in cast-iron pipes securely fastened under the decking and provided with inspection boxes every 20ft. apart, also service boxes at every lamp column. The lamp columns are provided with two arms, each carrying a clear glass globe containing three 50-c.p. lamps at the height of 20ft. from the deck. The light on either arm can be switched off or on by means of switches placed in the base of the column. At each of the three landing stages is placed an ornamental arch 13ft. high, with one 50-c.p. lamp suspended. In the open space near the bandstand is fixed a lattice pole 45ft. high, carrying three 3,000-c.p. Crompton arc lamps, which light a space of 30,000 square feet so effectually that small print may be read easily at any part. The bandstand itself is lighted by eight pendants, each carrying lamps of 16 c.p. The lavatories, ticket offices, entrances, gangway, and the pontoon railway station are all well lighted and provided with suitable fittings. The work has been carried out by the contractor, Mr. F. Shalders, of Southampton, assisted by Mr. T. Davis, under the supervision of Mr. J. G. W. Aldridge, 9, Victoria-street, S.W., electrical engineer to the Harbour Board.

Electric Submarine Boat.—Considerable interest has been recently excited in America by the practical trials of an electric submarine boat built by Mr. George C. Baker, of Chicago, at Detroit. A representative of the *Western Electrician* was the first passenger on this strange craft, and in the issue for June 4th gives some account of his experiences, with a section and many photographs of the boat in action. The boat is built of oak strips 6in. wide, nailed flat side together, covered with steel sheathing, and is 40ft. long, cigar-shaped, the centre being 13ft. deep by 8ft. across, and the boat weighs 75 tons loaded. It has a 60-h.p. boiler inside, driving a 35 nominal horse-power engine, which is used to drive a dynamo for charging cells. The electrical equipment consists of a 50-h.p. Jenney motor and 232 Woodward cells. The motor is wound for 220 volts and a maximum speed of 900 revolutions. It is geared to two four-bladed screws to run at 300 revolutions. When running as generator the dynamo is speeded up to 1,025 revolutions. The cells are charged at any convenient spot ; then the fire is put out and the smoke-stack drawn down. Water ballast is let in, and the boat is submerged to the required depth, the maximum depth attained on the trip being about 10ft. This trip was for 35 minutes, but afterwards the boat was closed and run part of the time above and part under water for two hours and 44 minutes. A curious feature about this vessel is that no special provision is made at present for freshening the air. Mr. Baker thinks that two men could live in the closed boat for several hours and not suffer for air, and for trips of an hour no inconvenience is felt. The boat is calculated to stand with safety the pressure of the water at 150ft. below the surface, or 75lb. to the square inch.

Taunton.—The Council have instructed the surveyor (Mr. J. H. Smith) to prepare a scheme and estimate for increasing the electric lighting of the town by seven new lamps, and at the same meeting the report of the Electric Lighting Committee was adopted to the following effect : "Your committee have, in pursuance of the instructions given them by the Council, had interviews with the directors of the electric lighting company, and recommend the Council—1. To instruct the town clerk to take the necessary steps to obtain a license to supply electricity at the earliest possible time. 2. To enter into a contract with the company to purchase the whole of the buildings, plant, and works of the company for £9,300, and to complete the purchase as soon as possible, subject to the sanction of the Local Government Board to the borrowing of the money required for the purchase and extension of the business, and without prejudice to the existing contract with Mr. Massingham for lighting the borough, the company undertaking to cancel their agreement with Messrs. Laing, Wharton, and Down before the completion of the purchase. 3. To authorise this committee to take the necessary steps to carry out the foregoing recommendation. Your committee have asked the Lighting Committee to prepare a scheme for the extension of the electric light of the town by the addition of seven new lamps. Your committee have enquired of the Local Government Board whether, in case the Council shall purchase under a license and temporarily borrow the necessary money for a short period, there will be any technical difficulty in afterwards borrowing a sufficient sum to cover such temporary loan and carry out the necessary extension, the last-mentioned sum to be repayable by instalments extending over a long period. Your committee hope to receive a reply from the Local Government Board, and to lay the same before your Council meeting on the 14th inst."

Alternators in Parallel.—The question of working alternate-current machines in parallel is one that has a fascination, as well as a great importance, for electrical engineers. In the large central stations of the future the possibility of coupling alternators in parallel will evidently be utilised if gain, either in economy or efficiency, is to be obtained, and the accounts of experiments or runs with

parallel coupled alternators will have a value as guide. Mr. E. G. Pink, recently chief engineer to the Electricity Supply Company of Madrid, during the first week in November last year, made a series of interesting experiments in this direction with success. At the Madrid station there are six alternators of Elwell-Parker make, 100-unit machines, supplying at 2,000 volts various high-tension circuits in the town, and for the theatres and cafés. Four dynamos are usually required at times of highest load, and these four dynamos were run in parallel during the week in question. The process was as follows: When the current from the first dynamo showed about 30 amperes on the ammeter, the second machine was got in step. A test lamp arranged in the usual way was used, the primary being double, one wire from each dynamo, and the lamp on the secondary showed by its steadiness when the two machines were in step. The third and fourth machines were put on from 6 to 9.30 p.m., and then switched off one after the other as the demand decreased. On a dark night the second dynamo was switched on at 30 to 35 amperes, and on bright nights 45 to 50 amperes. The working of the machines was perfectly successful, the rope gearing ran evenly, and there was a reduced coal bill. The only difficulty was with the circuits, which had not been arranged for a constant pressure at the station, and some burnt rather too brightly when others were just right. The circuits usually varied from 2,200 down to 2,040 volts, the usual being 2,160 on full load. Mr. Pink arranged transformers on his circuits when working in parallel, with choking coil for the near circuits. The highest total current was 176 amperes. The great advantage of such parallel running would be in safeguarding the circuits. Every alternator made can run 25 or 30 per cent. above its normal for two or three hours; if connected in parallel three machines could in case of accident take the whole load of four, without unduly severe strain, and this advantage, besides that of more economical running generally, seems to indicate that parallel alternate-current running will prove beneficial when properly arranged.

Electric Railways.—We are glad to see there is good prospect of another of the electric railway Bills becoming law this session. Three opposing petitions which had been deposited in the case of the measure to enable the Central London Railway Company to make a further railway from Mansion House to Liverpool-street having been withdrawn, the Bill was on Wednesday brought before Mr. Courtney, and duly passed as an unopposed piece of private legislation. On Thursday it was proposed to suspend the standing orders in its favour so that they may speedily reach the Lords. The following information given before the committee will be interesting to electrical engineers: Mr. Cripps, Q.C., in opening the case for the Great Northern and City Railway, said the proposal was to construct a line from Drayton Park to Moorgate-street, so that trains on the main line of the Great Northern could run right into the City. It was felt that the traffic of the Great Northern was so enormous that it should not be dealt with by any system of changing trains. Near Drayton Park there would be a depôt for the development of electricity. The engines of trains running through would be changed at Drayton Park, from which station on to the City electrical lomotives would be used. Sir Douglas Fox said they proposed to use a 16ft. tunnel; the steepest gradient was 1 in 45 for a short distance. The estimated cost was £1,199,325, to which must be added £250,000 for the lifts, the electric installation, and plant. They had satisfied themselves that it was perfectly practicable to run a train with an electric engine, and Messrs. Siemens Bros. were prepared to undertake it. Mr. Siemens gave evidence to the effect that electric traction could only be applied economically in cases where there were frequent trains for long hours on account of the large first outlay. He referred to the contract in America to take the traffic of the Baltimore and Ohio Railway through Baltimore by electric locomotives. Sir Henry Oakley, general manager of the G.N.R., said there was no doubt rapid changes of engines could be made at Drayton Park, and he could not doubt that such a line to the City would prosper. Mr. Bell, general manager of the Metropolitan Railway, in objecting, said his directors had tried to make arrangements for experiments in electrical traction and had offered favourable terms to electrical engineers, but without satisfactory result. Other objections were heard, but the Bill was reported for the third reading.

The Proposed Telephone System.—On Wednesday Mr. Goschen's Select Committee of the House of Commons met to consider the Telegraph Bill now before the House, which proposes to authorise the expenditure of a million pounds, drawn from the Consolidated Fund, for the development of the telephonic system of the United Kingdom, and in particular with a view to purchase the main lines of telephonic communication already existing. In the absence of the Chancellor of the Exchequer, Sir James Fergusson took the chair. Mr. J. C. Lamb, assistant secretary to the General Post Office, confessed that telephones had made a difference in the telegraph revenue. From a return made some time ago it appeared that in a given period the rate of increase of the telegraphic business of the whole country was 108 per cent., whereas in the same period the rate of increase between busy districts where telephone wires were laid was much less, ranging even as low as 30 per cent. In answer to the chairman, the witness said that it was proposed to relinquish the charge now made to the companies for telegraph and for wires connected with local post offices. In the case of railway companies a commission of 1½d. a message was made, and the railway companies had to provide the operator, to take the message over the counter, and to transmit the message; the telephone companies, on the other hand, had not these expenses. It was also proposed to allow the telephone companies to use the houses and shops of some post offices as call offices. These concessions were made to the telephone companies on condition of their giving up their trunk lines. It was proposed to confer by the Bill moderate statutory powers on the companies for the erection of overhead wires, and to place them under obligation to obtain the consent of the local authorities. The Post Office intended to establish main lines between London and Belfast and Edinburgh, and branches to other centres. About £400,000 would be spent in additional lines, and £600,000 would, he thought, enable them to purchase the trunk lines and fill up gaps. In answer to Sir Richard Temple, the witness said that there was no telephonic communication at present between England and Ireland, and it was part of the Government scheme to establish one by submarine cable. Mr. R. Hunter, solicitor to the Post Office, stated that he had prepared some amendments to meet the views of municipal corporations. Mr. J. S. Forbes, chairman of the National Telephone Company, said that at the present time the telephone companies conducted a great deal of their business very badly, but this was the fault of Parliament in not allowing them the necessary powers. He thought the Government should either take over the companies altogether or co-operate with them in carrying on the telephonic service. The best means of doing that would be to give the companies further powers. The committee adjourned till Thursday.

A NEW SYSTEM OF ELECTRIC PROPULSION.*

BY H. WARD LEONARD.

In the distribution of electricity from a power station for the operation of electric railways the only commercial method to-day is by the use of a system of constant E.M.F. operating the motors in multiple arc with each other, and at the present time every consideration of economy and automatic regulation seems to indicate that the constant E.M.F. multiple-arc system will always be the best for such distributions.

In the use of electric energy by motors operating under conditions of varying speed and torque the best results as regards economy and regulation are obtained when the electric energy utilised has a voltage varying directly as the speed and a current varying directly as the torque, for it is evident that under these conditions the electric energy required will be always proportional to the power developed.

If we could operate from the constant-potential system a shunt-wound motor running at a constant speed and could interpose between this motor and the axle some device equivalent in its effect to an infinite number of different sets of mechanical gears, so that we could make use of any reduction desired, it would enable us while using a constant power to increase the torque as we decreased the speed and *vice versâ*, which is just what is desired in railway practice where the least torque is required when at full speed on the level and the greatest torque is required at the slow speed in starting and in operating on a grade. Numerous and very ingenious devices have been invented for accomplishing this variable mechanical reduction, but on account of the complication, noise, and unreliability, they have never proved successful.

The writer has recently devised an electrical method of securing all the results which could be obtained from such a set of gears described, with a freedom from the noise, wear, complication, and rigidity which such a set of gears would necessarily involve. The following is a general description of the arrangement proposed: Each axle is driven by a gearless motor, either directly or by means of a connecting rod. The fields of these motors are excited directly from the constant E.M.F. of the line and independently of the armature circuit. Beneath the car and between the axles there is suspended a motor-generator, each armature winding being in a separate field. The motor portion of the motor-generator—which will, for convenience, be called the power converter—is shunt wound and connected just as a shunt motor is for use upon ordinary constant-potential circuits. The field of the generator portion of the power converter has its field connected across the line and has inserted in it a regulating and reversing field rheostat. This field circuit is independent of the armatuse circuit. The generating armature of the power converter is in metallic connection with the armatures of the gearless propelling motors. It will be noticed that this circuit, including the armature, is a distinct and separate metallic circuit having no connection with the line in any way.

Suppose now that our shunt motor is running at full speed, and that our controlling rheostat in the generator field circuit is at its central position, so that the generator field circuit is broken. Although the generator armature is being driven at full speed it is revolving in a field having no magnetism except the residual magnetism, and hence produces practically no volts. Let us now move our controlling switch so as to place the generator field across the line, but with a resistance in series with the field, of 10 times the resistance of the field coils. We now get a slight excitation of the field and a development of volts at the brushes of perhaps 40 volts. This voltage will produce a current through the armatures of the driving motors dependent upon the ohmic resistance of this circuit only; and hence, even at this low voltage, a large current will be produced, which, being in a field of full strength, will cause a torque sufficient to start the armature. The speed of the armature will of course be governed by the counter E.M.F. which its revolution produces in its strong field; and hence, just as in the case of a shunt-wound motor, its speed will be practically constant so long as the E.M.F. supplied is constant.

If we now gradually increase the magnetic field of the generator by cutting out resistance by moving the controlling switch, we will gradually raise the E.M.F. of the armature circuit, and with it the speed of the driving motors. Since these armatures are revolving in a constant field, the torque they produce will be exactly proportional to the current in them, and the current will automatically flow exactly as is required to produce the necessary torque to maintain a speed such that the counter E.M.F. will approximately equal the E.M.F. supplied by the power converter. Thus it will be seen that the speed of the car will be dependent upon, and proportional to, the E.M.F. supplied by the power converter, and the torque or tractive effort will be dependent upon, and proportional to, the current supplied by the power converter.

Let us suppose that 60 amperes flowing through the armatures in fully excited-fields will produce a torque sufficient to move the load when upon a grade. It is evident from what we have seen that 40 volts from the power converter will produce this current. Hence, by an expenditure of 2,400 watts in the secondary circuit, or a total power, including field excitation, etc., of about 8 h.p., we can start a fully-loaded car upon a grade.

Under the existing systems, we would need the same 60 amperes in the same fully-excited field, but would necessarily use the full voltage of 500 volts, and, therefore consume energy represented by 30,000 watts, as against possibly 6,000 in this system. The current from the line in starting the car under ordinary conditions by this system would be about 12 amperes at 500 volts, instead of from 60 to 100 amperes at 500 volts.

In practice, the controlling switch lever can be instantly thrown from its central position to its extreme position for full speed. The field magnetism of the generator is rapidly increased, and consequently also its E.M.F., which in turn causes a gradual acceleration of the car.

The current in the armature circuit, and consequently the torque, is quite large in the beginning; but the E.M.F. at this time is quite low, so that the total watts are low; as the inertia is overcome and the counter E.M.F. begins to approximate to the impressed E.M.F. the current falls off and finally becomes constant at an amount necessary to produce the torque required to maintain the speed. The current from the line, and hence the power, gradually increases from zero to the amount required at full speed, but at no time, either at the start or during the acceleration, is the energy from the line greater than that required when we are operating at full speed. It will be noticed that the effect is the same as though we first operated through a set of gear wheels, giving an extremely great reduction of speed and then rapidly changed the ratio of gearing, until finally we operated at full speed, with no reduction.

With our hypothetical gears we could, when running at speed, rapidly increase the ratio of gearing so that the movement of the car would tend to drive the shunt motor faster and faster. This would convert it into a generator forcing current back into the system, which production of electrical energy would act as a brake and gradually bring the car to rest.

Just so, if, while running a full speed, we suddenly place our switch lever at its central position the field of the generator will gradually reduce the strength, and the counter E.M.F. of the propelling motors will soon exceed that of the generator. The momentum of the car will now be driving our gearless motors as generators, which will supply current to the former generator, operating it as a motor, causing it to drive the shunt motor coupled to it, as a generator, which, in supplying energy to the line, will act as a brake, and smoothly but rapidly bring the car to rest by converting the energy stored up and represented in the movement of the car into electrical energy, which will tend to relieve the work at the central station. Similarly, a car descending a grade and tending to accelerate in speed can be made to move at any desired speed without the aid of any mechanical brakes and the energy represented by its falling weight will

* Paper read before a General Meeting of American Electrical Engineers at Chicago, June 6th.

TABLE I.—DUTY OF CAR: SHOWING VARIOUS LOSSES EXPRESSED IN WATTS.

Various losses involved.	8 tons at 12 miles per hour on level.			8 tons at 3 miles (or 5 tons at 5 miles) per hour on 5 per cent. grade.			8 tons at 1¼ miles per hour on level.		
	Full speed, 1-16 full torque; armature current, 10 amperes.			¼ full speed, full torque; armature current, 60 amperes.			1-10 full speed, 1-6 full torque; armature current, 10 amperes.		
	Power converter.		Driving motors.	Power converter.		Driving motors.	Power converter.		Driving motors.
	Motor part.	Gen. part.		Motor part.	Gen. part.		Motor part.	Gen. part.	
Field	250	275	250	250	60	250	250	25	250
C^2 R in armature	160	60	60	250	2,000	2,000	20	60	60
Friction	60	60	120	60	60	30	60	30	10
Foucault currents, hysteresis, etc.	200	400	400	200	50	50	200	10	10
Total	670	795	830	760	2,170	2,330	530	125	330
Total watts wasted	2,295			5,260			985		
Watts of work done	4,000			6,000			400		
Total watts absorbed	6,295			11,260			1,385		
Amperes at 50 V.	12·6			22·5			2·8		

be converted into electric energy and the car will become a moving feeder supplying energy to assist the generators at the central station in the operation of other cars.

It will be evident from what has preceded that with this power converter system we can propel a car upon any practicable grade with a consumption of power no greater than is required to operate the car at full speed upon a level, by merely reducing the speed to the required extent.

In street railways of from five to ten cars, this is of great importance, for it means that we can equip a road with about 6 h.p. per car, as regards the engines and dynamos, and that our conductors can be reduced to about one-third of the amount at present necessary, for we will never require more than 20 amperes at the distant point, where to-day we have to provide for 60 amperes with the same loss and same initial E.M.F.

Under the rheostat system the plant is severely taxed when an unusual crowd must be moved from a certain point, and it is then, when it is of the greatest importance that no breakdown should occur, that it usually does occur. With this power converter system we could, upon a five-car road, start up and move with perfect safety 10 or even 20 cars from the most distant point on the road, though, of course, at a reduced speed, but the crowd would be handled with perfect success and without subjecting any portion of the plant to any unusual strain.

In the large cities it is no unusual sight to see an electric car moving at the slowest possible speed for perhaps several blocks. Perhaps 12 amperes are required to obtain the necessary torque. This at 500 volts is 6,000 watts. The power required for this slow motion by the proposed system would not exceed one-fifth of this amount.

The following tabulated statement (Table I.) shows the results we may expect to obtain by this system in operating with a fully-loaded car under three different conditions: First, at 12 miles per hour on the level; second, at three miles per hour on 5 per cent. grade; and third, at one mile per hour on level.

In arriving at the losses, as indicated, the motor part of the power converter has been assumed as having the following features: E.M.F., 500 volts; current capacity for 10 hours' continuous duty, 15 amperes; resistance of shunt field winding, 1,000 ohms; armature resistance, 1·1 ohms. The generator portion of the power converter and the driving motor are assumed as having the following features: E.M.F., 500 volts; current capacity for 10 hours' continuous duty, 40 amperes; resistance of field, 900 ohms; armature resistance, 0·55 ohm. The rolling friction with gearless motors on good level track is assumed as 20lb. per ton. Car is assumed to be eight tons in weight full loaded, and five tons for moderate load.

We find that with 12 tons moving at 12 miles per hour on a level we will require 12·6 amperes, which is practically the same as by present series motor systems. With eight tons moving at three miles per hour upon a 5 per cent. grade 22·5 amperes will be required, which is abou one-third of the power required by present systems. With eight tons at one mile per hour on level 2·8 amperes will be required, which is about one-fifth of by present systems. With five tons moving at five miles per hour on 5 per cent. grade 18·5 amperes will be required, which is about 40 per cent. of the power required by present systems.

Let us examine some of the advantages that this method seems to offer over the existing methods, starting at the car and considering the entire equipment back to the boiler.

In order to place before you the opinions of some of the best authorities on the questions involved, I shall quote freely from "The Electric Railway" (Crosby and Bell); Parshall's "Methods of Electrically Controlling Street Car Motors," "Comparative Test of High and Low Speed Engines in Electric Railway Work," by Charles W. Wason (*Electrical Engineer*, April 27, 1892); "The Practical Operation of the Gearless Motor," by S. H. Short (*Electrical World*, April 16, 1892); "Load Diagrams of Electric Tramways and the Cost of Electric Traction," by A. Reckenzaun (*Electrical Engineer*, London, March 25, 1892).

The cost of car equipment will be increased by the cost of the motor-generator, but as a partial offset to this we have saved the rheostats, two expensive controlling switches, and a complex system of wiring. Our motors, having constant and fully-excited fields, will operate absolutely without spark under all conditions. The control of the car will be entirely accomplished by a small switch and rheostat, handling never more than one-half of an ampere and occupying a space of 1ft. square and 1in. deep over all.

As regards efficiency, we will have the advantages of the present system under all conditions. For long runs upon the level we will, by a suitable switch, connect the driving motors directly to the line and secure an efficiency of 90 per cent. for our motor. As regards depreciation, we will have the advantage of no rheostats or controlling switches to burn out, and with no sparking and no connection with the field circuit we will have the minimum liability of burning out armatures. Our fields will have no tendency to burn out, since they are not subject to the excessive currents which the present series fields are. The current in our fields will be independent of the load.

As to field windings and rheostats in existing methods, Parshall says: "With 25-h.p. motors, an external resistance of 10 to 12 ohms is required. Lessening the duty of the rheostat is a very important point, since as yet it has been found exceedingly difficult to construct a cheap rheostat that could be placed under the car in the small space available and dissipate so large an amount of energy as is required when the car is to be run for a considerable time at a speed so low as two or three miles an hour. Any method of control that has lessened the energy to be dissipated in the rheostat has in general been considered with favour, since there has been a corresponding diminution of trouble in each case that the energy to be dissipated has

been lessened. The range of speed without the use of a rheostat is determined by the limit to which it is safe to heat the magnets."

Crosby and Bell say: "In using this method (commutated fields) the principal difficulty has been met with in disposing of the excessive heat necessarily generated in the compact mass of field windings. The practical problem has been to secure a convenient rheostat. The principal sources of loss in our present street railway motors are the regulating devices and the gearing. With the motors and the gearing generally employed, the average commercial efficiency of the combination is probably not often in excess of 65 per cent., giving a total commercial efficiency for the system, from engine to car wheel, of 39 per cent. This, of course, is but an estimate; but taking all the factors into consideration it is probable that the average of the roads now in operation would fall quite nearly to the point indicated. In very few cases would it fall below 30 per cent.; in still fewer would rise about 40 per cent."

Regarding the power required to start a car on existing methods, and to operate it upon level grades, Crosby and Bell say: "With the ordinary car equipment of two 15-h.p. motors, and the usual speeds, from eight to twelve miles per hour, experience has shown that five to six electrical horse-power is necessary on nearly level tracks. The amount of current ordinarily taken in starting a car is momentarily more than 50 amperes, which at the ordinary voltage corresponds to about 25,000 watts."

Reckenzaun says: "If we calculate from the accepted coefficients of resistance to traction on common tram rails, we find that an ordinary tramcar will require about three to four horse-power for its propulsion when once in motion." He says of Thomson-Houston car: "The maximum current at any time was 75 amperes." Of Sprague motors: "Here again we observe a maximum current of 75 amperes. Westinghouse motors, maximum current 95 amperes."

Short finds that 80 to 100 amperes are required to start a car and says: "On this road the traffic is very heavy, although grades are light."

Leaving the car, let us now consider the line. It will be evident from what we have seen that we can reduce the amount of copper to one-half the present requirements, as we never will require the enormous currents at present called for in starting and upon heavy grades. Or, to put it in another way, with the existing conductors we could run twice as many cars as at present, with the same loss in the conductors.

Now, let us look at the generators and the prime movers, whether steam engines or waterwheels. Under existing systems for roads of from five to ten cars, it is necessary to install about 20 i.h.p. (rated at ¼ cut-off) per car and about 16 kilowatts per car in generators. Also about 20 h.p. per car in boiler capacity. This large equipment is necessitated by the occasionally very large demands for power and the inefficiency consequent upon this.

Under the proposed system it is not necessary to provide power in excess of 15 h.p. for any car under any conditions, and since in practice most of the cars will be operating at less power than this, we need only install engine, dynamo, and boiler capacity of 8 h.p. per car, instead of 20. Or, to express it another way, we can operate with existing boilers, engines, and dynamos at least the double the number of cars they can at present supply.

Crosby and Bell recommend, for a five-car road: "An equipment consisting of two 40,000-watt dynamos, one 80-h.p. high speed simple engine belted directly to them, and two boilers of about 50 nominal horse-power each."

Now let us look at the economy of the operation of the station. With the extremely fluctuating loads of existing systems, the economy of the entire generating plant is very low. The stations of three roads which have been tested give for the combined efficiency of engine and dynamo 40 per cent., 54·6 per cent., and 62·8 per cent. respectively. If the load can be kept approximately constant, the combined efficiency of engine and generator should be about 75 per cent., and in the proposed system the load will be sufficiently uniform for us to expect an efficiency equal to this, and because of the nearly constant load we can produce a horse-power on about 25lb. of water, while in present practice for small roads about 50lb. of water per horse-power is a fair figure, and the best published result thus far obtained, even when the average horse-power rose to 750 h.p., is 28lb. per horse-power, as found by Wason, at Cleveland, in operating a total of 71 motor cars.

With the present systems the average indicated horse-power per car is about 12 h.p., which, on account of fluctuating load, requires at least 36lb. of water per horse-power, or about 420lb. of water per car per hour.

With the proposed system we will operate with an average of about 8 i.h.p. per car, which, on account of the steady load, will be produced with about 25lb. of water per horse-power, or 200lb. of water per car per hour. That is we require about 50lb. of coal per car per hour by present systems, and about 25lb. of coal per car per hour by proposed system, or a saving of 50 per cent. in the coal and water required in favour of the proposed system.

On this subject of fluctuating loads and their effect, Crosby and Bell say: "A record of 10 minutes on a recording ammeter may give some faint idea of the condition of things. It will be seen that at one point the output jumped from zero to 150 h.p. and back inside of a single minute, and during the latter five minutes shown in the diagram there were no less than 25 sudden variations of 50 h.p. to 100 h.p., each taking place within a few seconds. The road from which this record was obtained is four miles in length, and was operating seven cars at the time of the test."

Reckenzaun says: "These abrupt changes have the effect of reducing the efficiency of the whole system to a comparatively low figure."

Church says (*Electrical Engineer*, April 27, 1892) that the best compound engines will show an economy of only 28lb., and the usual compound engine an average duty not better than 35lb. to 40lb. The same is true of every form of non-compounded engine, whether high speed or low speed, both of which show a tremendous falling back of fuel duty under variable load.

Let us now examine the comparative first cost of a railway of moderate size—say, from five to ten cars—equipped by present systems and by the proposed system. The detailed figures per car are given in Table II.

Table II.—Showing Probable Comparative First Cost per Car by Present and Proposed System.

	Present system.	Proposed system.
Steam plant, generators and conductors per car (steam plant 1,000, generators 700, conductors 500)	$2,200	$1,100
Motors (two 15-h.p. equipments)	1,800	1,400
Power converter	0	900
Controlling switches, cables, rheostats, etc.	200	30
Total first cost per car	4,200	3,430
Saving in favour of proposed system per car	—	770

Table III. gives a summary showing the features of the proposed system as compared with the corresponding features of the present system.

Table III.

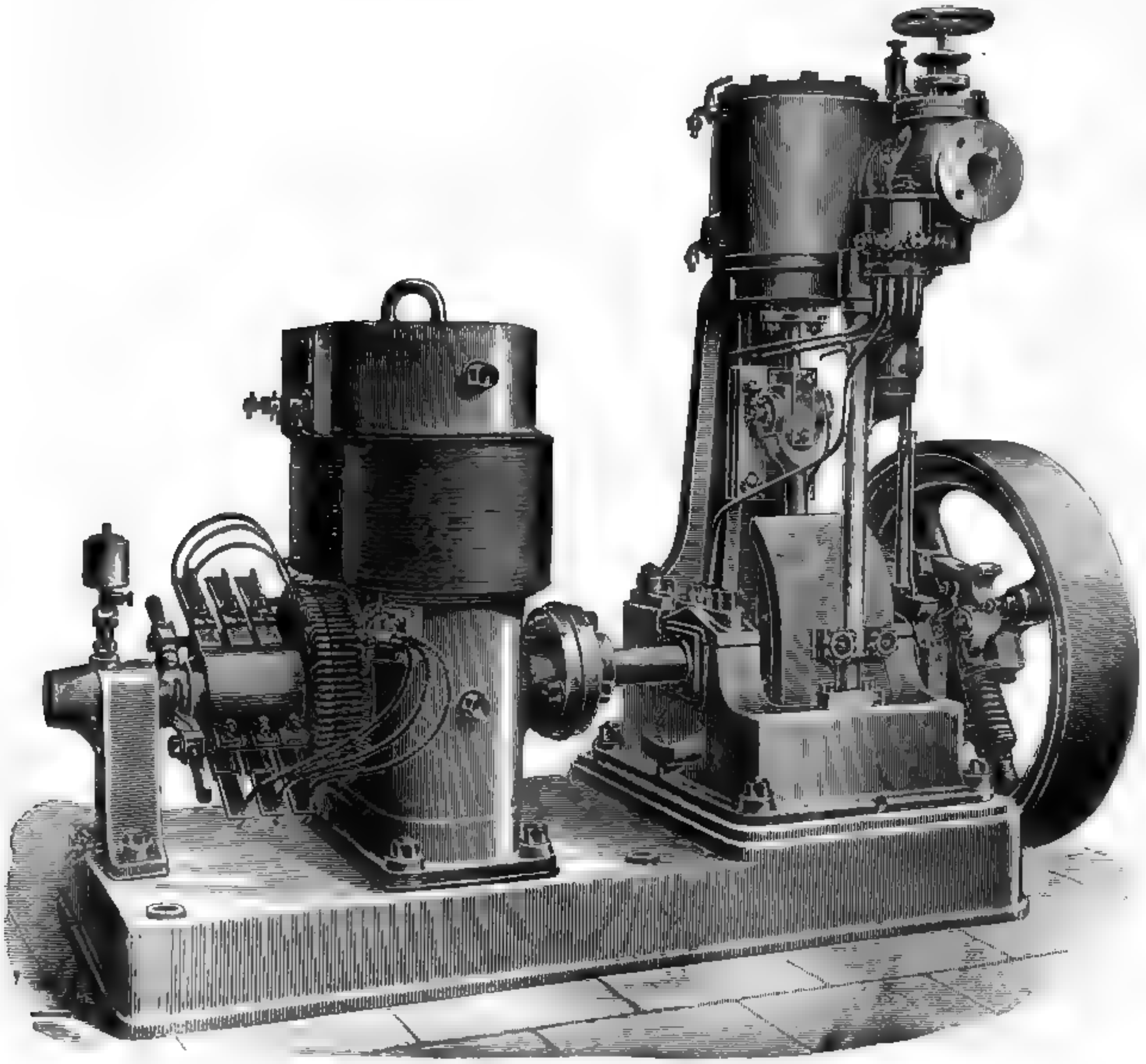
	Present system.	Proposed system.
First cost of steam plant, generators, conductors, and car equipment per car	$4,200	$3430
Amperes at 500 volts required to start full load on level	75	2·8
Amperes at 500 volts for full load at full speed on level	12·5	12·5
Amperes at 500 volts to start full load on 5 per cent. grade	125	10
Amperes at 500 volts for working speed on 5 per cent. grade	60	22·5
Amperes fed back to system in coming down 5 per cent. grade	0	10
Pounds of coal per car per hour	50	25

The features of the proposed system which seem, at first sight, to be very objectionable are: The increased cost of the car equipment and the fact that we are adding an additional machine, having two fields, two armatures, and three bearings: but, as we have seen, there is only an apparent increase in the first cost, for the saving in the generators and distributing plant far exceeds the additional cost of the car equipment; and the use of the motor-generator for elevators, travelling cranes, etc., has demonstrated that, as regards the attention it requires and the

depreciation it suffers, it has a marked advantage over the rheostat or commutated field used in the present methods of operation.

SHIPLIGHTING.

The lighting of ships was one of the first great fields of usefulness in which the electric light proved its efficiency, and while central installations are springing up on land on every side, the department of shiplighting still continues as busy as ever. The following ship installations completed during the past month by the Newcastle firm, Messrs. J. H. Holmes and Co., bear telling witness of the continued activity in this branch of electric lighting.



Messrs. J. H. Holmes and Co.'s Coupled Ship Lighting Plant.

"*Le Progrès.*"—This vessel has been specially built by Messrs. W. G. Armstrong, Mitchell, and Co., for the service of the Compagnie Universelle du Canal Maritime de Suez, to convoy the large tank steamers which are intended to trade to the East through the Suez Canal. The vessel is of a special description, and is fitted with powerful pumps on deck, so that in case of a ship being damaged or grounding, the tank tug would immediately be able to pump out of the large steamer and into her own tanks 500 tons of oil. The tug will also carry a set of booms, which can be quickly jointed together, forming a floating cordon, so as to retain within the cordon any oil which may have leaked on to the surface of the water. This boat was fitted by Messrs. J. H. Holmes and Co. with a powerful projector, two 20-ampere arc lamps, and two 10-ampere arc lamps, also 24 16-c.p. incandescents, and seven 50-c.p. incandescents. They have orders to light five petroleum boats, for Sir W. G. Armstrong, Mitchell, and Co., which will make a total of 18 boats of this class lighted for that company, besides petroleum boats for other companies. It is a class of boat which requires very special attention to details, owing to the action of the petroleum vapour on the fittings and wires, and the danger which might accrue from the occurrence of any spark. The Holmes coupled plant running at about 250 revolutions per minute, fitted with automatic expansion governor was used, giving 70 volts and 300 amperes. Each arc lamp is run on an independent circuit having separate lead and return from the main switchboard in the engine-room, where all the resistances are placed.

"*Skerryvore.*"—This boat sailed on June 9. The length over all is 350ft.; breadth, extreme, 42ft.; depth, moulded, 29ft. 6in.; gross tonnage about 3,400 tons. The vessel, which has been built to the order of Messrs. Farrar, Groves, and Co., of London, will class 100 A1 in *Lloyd's Register*, and has been built under special survey. She is of the spar deck type, with a half poop aft for accommodation of captain and officers, and a half forecastle for crew, engineers being berthed in a large house abaft engine casing. She will be fitted with five steam winches, steam windlass, extra large donkey-boiler, stockless anchors, double derricks to hatches, and every modern appliance for speedy loading and discharging. The engines are by Messrs. Blair and Co., Limited. Cylinders 24in., 40in., and 66in. by 45in. stroke, and two single-ended boilers, having a working pressure of 160lb. The electric lighting plant was also fitted by Messrs. J. H. Holmes and Co. On this boat they installed 80 16-c.p. incandescent lamps, a "Suez Canal" projector, and arc lamp. The dynamo is driven by an endless rope, over jockey pulley, from a vertical engine. The dynamo speed is 550 revolutions per minute, giving

150 amperes and 65 volts. The dynamo is mounted on sliding rails for taking up slack in the rope gearing.

"*The Duke of Fife.*"—This vessel, built for the Dublin and Glasgow Steam Packet Company, went last month on her official trial trip in the Firth of Clyde. The vessel, which has been specially designed for the company's cross-channel trade, was built by the Ailsa Shipbuilding Company, Troon, and engined by Messrs. Dunsmuir and Jackson, Govan. Her gross tonnage is 997, her length 253ft., her breadth 31ft. 9in., and her depth 16ft. The engines are of the triple-expansion type, with cylinders 26in., 41in., and 66in. in diameter, and a stroke of 42in. She runs at a speed of 15½ knots. This ship was installed by Messrs. Holmes and Co. with 110 16-c.p. lamps on the single-wire system. In cattle spaces all wires were lead-covered, and their special cattle fitting was used, with cast-iron lid for protection when this space is used for cargo. The generating plant consisted of 7in. by 6in. vertical engine, open type, automatic expansion governor, coupled direct to Castle dynamo—13in. armature, speed 275 revolutions, giving 60 volts and 110 amperes.

"*Nina Mendl.*"—This is a steel ship 307ft. by 38·6ft. by 21ft., built to the order of Messrs. F. Mendl and Co., London, fitted with all modern appliances and improvements. The engines are on the triple-expansion principle, working on three cranks, and were supplied from the Central Marine Works. The cylinders are 26in., 36½in., and 62in. diameter, with a piston stroke of 39in. The boilers are of large size, built of steel, and give an ample supply of steam at 160lb. working pressure. This boat was fitted up with 75 lights, driven by Holmes's coupled plant, fitted with automatic expansion governor, the speed being about 330 revolutions per minute. On the trial it was found impossible to detect any difference in voltage, even when suddenly switching off three-quarters of the load. Messrs. Holmes are now lighting the "Rosina Mendl" for the same owners.

"*Tasmania.*"—This is an express steel screw passenger steamer, built by Messrs. C. S. Swan and Hunter, Wallsend, to the order of Messrs. Huddart, Parker, and Co., Limited, of Melbourne and Sydney, and intended to augment their already large fleet in Australasia. The vessel is about 300ft. long, and is fitted with very powerful machinery by the Wallsend Slipway and Engineering Company, Limited, Wallsend. Handsome accommodation is provided for over 200 passengers, complete with folding iron berths, folding lavatories, marble baths with hot, cold, fresh, and salt-water service laid throughout. The saloon, which is the full width of the ship, is very handsomely fitted, and over the dining-saloon is a grand music-saloon. In a house forward is the smoke-room, with walls of marble, and the floor of this room, saloon, and all berths is laid with encaustic tiles. Electric bells are fitted throughout, and no expense has been spared to make the passenger accommodation as luxurious and comfortable as possible. This ship sailed on June 5, and was fitted with 170 16-c.p. lamps. It had two coupled plants, each consisting of a vertical double-acting engine, cylinders 7¾in. diameter by 6in. stroke, at about 250 revolutions per minute, fitted with open-type automatic expansion governors. The dynamos are of the Castle type, slow-speed, 13in. armatures, giving 110 amperes at 60 volts. All fittings in the first-class accommodation are of white metal, silver plated. The wiring is on the single-wire system. Exposed wires are all protected by galvanised iron wire sheathing.

In ships Messrs. J. H. Holmes and Co. never use wires having an insulation resistance of less than 2,000 megohms per mile. All the ships are wired on the deck distribution system. A main switchboard is placed in the engine-room, from which mains are taken to suitable distribution centres and connected to an auxiliary switchboard, from which branches are taken to the various groups of lights, each branch being limited to 10 lights. All exposed fittings are damptight and mechanically protected from injury. All flexible cables are protected by a galvanised iron sheath. Their ship installations give great satisfaction, and they are now fitting up two similar ships to the "Tasmania," for the same owners, with electric light and bells. In addition to those mentioned, this energetic firm are at present engaged on boats in Glasgow, Edinburgh, Liverpool, Sunderland, Cardiff, Belfast, and other ports, and they have besides several large land installations in hand, of which we hope to give particulars shortly.

BRILLIE ELECTRICITY RECORDING WATTMETER.

We have this week had the opportunity of inspecting a specimen of the Brillié meter, now being tested by the Board of Trade. This meter has been brought over and introduced in England by M. G. P. Roux, who informs us that there are already over 1,000 of these meters in use in France. These have been working for more than a year, the principal users being the Continental Edison Company, who have 500; the Société pour l'Eclairage et le Transport de la Force, 200; and the French Ferranti Company, the Popp Company, and others have together over 400 Brillié meters. These figures will serve to show the importance accorded to this meter in France, and electrical engineers will be interested in having a detailed description, with illustrations, of the instrument.

One of the principal objections urged against the present type of electricity meters is their want of sensitiveness at small currents. M. Brillié in his new meter, as will be seen, has surmounted this difficulty in an ingenious manner. His meter belongs to the category of motor meters, but, in contradistinction to all the other motor meters brought forward up to the present time, this instrument has not to conquer the difficulty of friction, which in this class of meter is a constant source of error.

The Brillié meter comprises the following essential parts: 1. The electro-dynamometer, B I, of which the coil, B, is carried by an axle, A, to which is suspended, by means of stems, F, an annular disc of copper, D. This disc, D, therefore forms one with the coil, B, of the dynamometer, and turns with it. The axle, A, of the bobbin is itself suspended by a wire thin enough to make its torsion negligible in comparison to the strength of the dynamometer. Its displacement is, moreover, only through a few degrees. 2. A collection of small permanent magnets carried on an axle, C, placed in the same axis as A. These magnets are arranged so as to form a magnetic field traversing the disc, D. The axle, C, carrying these magnets can be rotated at various speeds by means of a motor, M. The direction of rotation of the axle C and the direction of the displacement of the coil, B, under the influence of the current to be measured, are opposite; these directions are indicated by arrows in the figure.

The action of the meter is as follows: If the axle, C, of the magnets is ratated, the displacement of the magnetic field will cause local currents to be generated in the copper disc, D; these currents exercise a resisting couple upon C, and, as reaction, a motor couple on A. These couples are therefore equal between themselves, and exactly proportional to the speed of rotation of C. In a word, the disc, D, tends to be drawn round by the rotation of C with an effort proportional to the speed of this axle. As the effort, in the opposite direction, exercised by the electro-dynamometer is proportional to the strength of the current, if we regulate by any convenient means the speed of C so as to maintain the axle, A, constantly in equilibrium, then the speed of C will be always proportional to the strength of the current passing through B I, and it will suffice to count the revolutions made by C to know the energy expended in the time given.

The speed of the axle C is regulated automatically by the movement of the axle A, which, in principle, makes and breaks, as it oscillates, the contacts in the circuit of the small electric motor, M. This simple contact is replaced in practice by a small special regulating rheostat, R, which regulates the speed of the motor by varying the current and not by breaking the circuit, at any rate until a considerable resistance without self-induction has been thrown in; sparking is therefore practically obviated.

The meter may be considered as composed of a powerful motor, M, furnished with an extremely sensitive speed regulator, formed by the magnetic pull of D, balanced against the action of the electro-dynamometer, B I; this speed governor

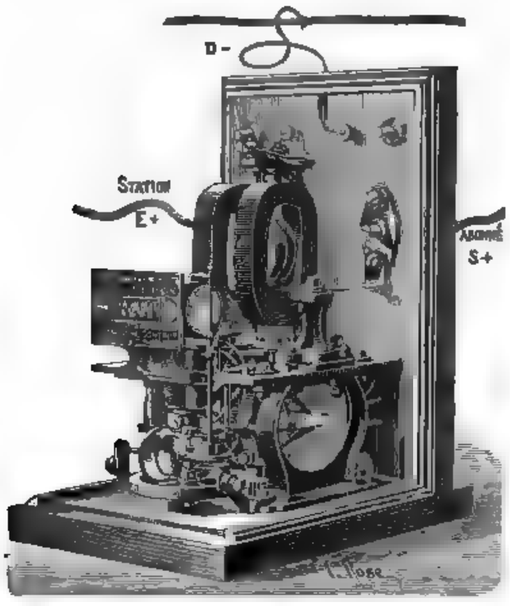
regulating the speed automatically as explained above, by maintaining it always proportional to the current passing in B I.

The starting of the meter takes place, therefore, as soon as the axle A is moved, the effort exercised by the motor, M, being independent of the effort exercised by B I, and depending for any given difference of potential only upon the position of the regulating rheostat.

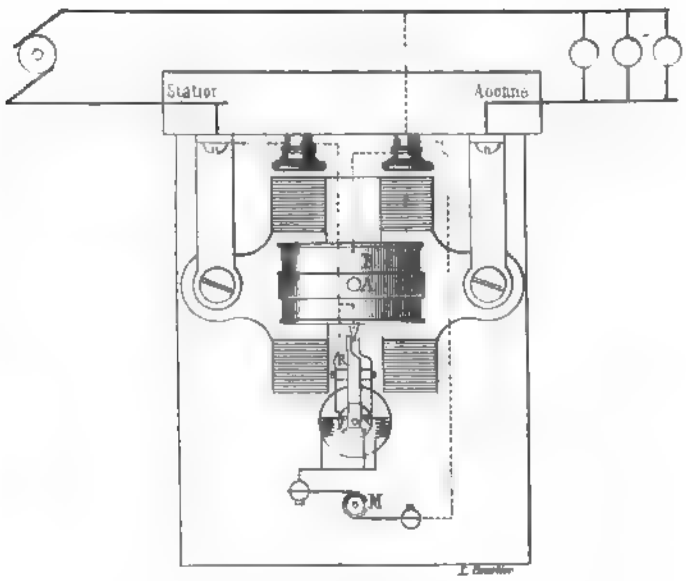
All the causes of error existing in similar instruments due to counter E.M.F., to friction of brushes, of pivots, of the air, etc., have no influence upon the exactitude of the Brillié meter. These passive resistances are, in fact, overcome by the motor, M, without modifying the speed it should have at any given moment, any more than the load, for instance, on a steam engine fitted with a good governor influences its speed.

We have seen that the electrical measuring instrument is an electro-dynamometer. This form of measuring instrument is one which allows the current to be best utilised to produce the greatest effect, all the turns of wire being in the position of maximum action, and the coil may be wound with many turns of wire. It follows that the meter consumes very little current in action. The resistance of the fine-wire coil being 10,000 ohms for a 100-volt meter, the consumption of current is one watt. As an example of sensitiveness of the Brillié meter, a 10-ampere meter starts certainly for 0·05 ampere. A meter recently constructed for 2,000 amperes starts at two amperes, or one-thousandth of its total capacity.

This meter is equally good for alternate as for continuous currents.



Brillie Meter—Showing Works.



Brillie Meter—Plan.

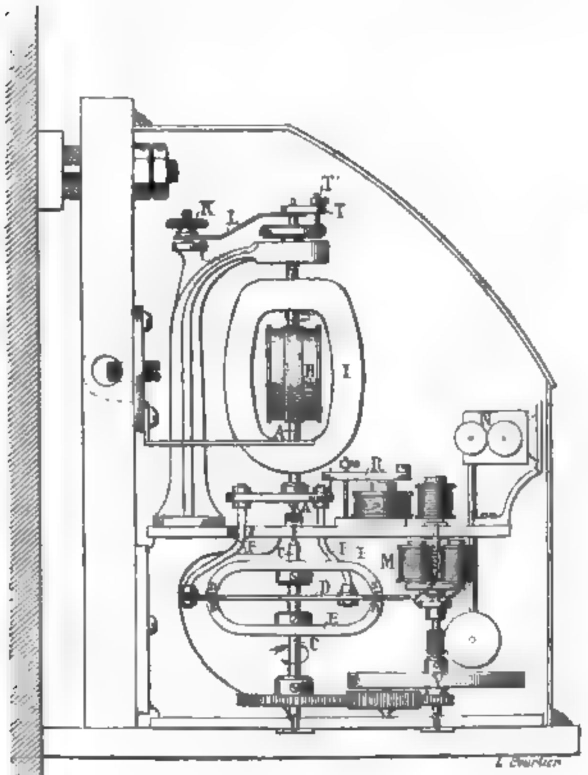


Fig. 1

Brillie Meter—Section.

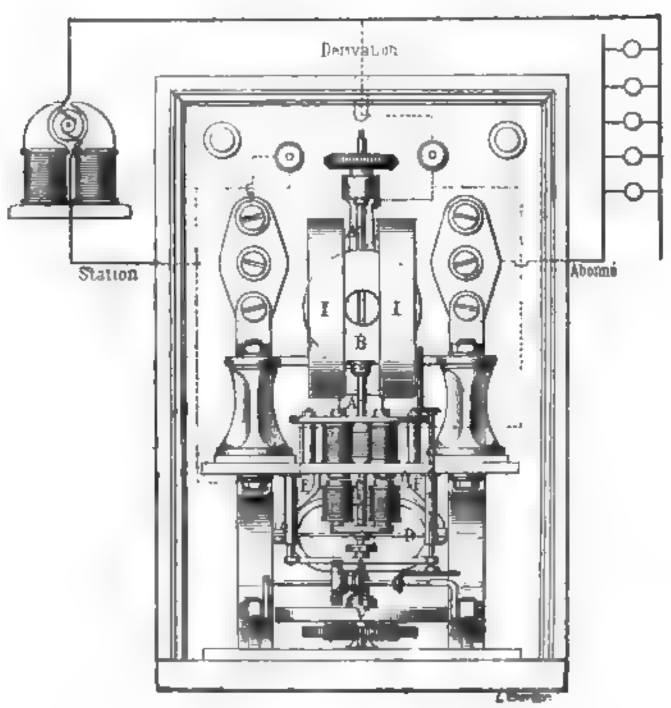


Fig. 2

Brillie Meter—End View.

In examining the Brillié meter, it seems at first sight a little complicated, but the problem itself of measuring and recording electrical energy is not a simple one, and the instrument which thoroughly solves the problem must necessarily be somewhat complicated, or else defective in action.

The experience obtained with over 1,000 of these meters now in use shows that in spite of its complicated appearance the Brillié meter gives most excellent practical results.

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CONTENTS.

TO CORRESPONDENTS.

TRACTION.

It is somewhat disappointing to know that so very little has been done in traction work on this side. It seems that, so far as pluck and go are concerned, this country is practically played out. Not only have the Americans caught on so far as traction work is concerned—and the greater part of what we know about it is due to their experience—but they are continually pushing ahead in new ventures and suggestions. This will be seen from the exceedingly interesting paper of Mr. H. Ward Leonard, which we are enabled to give by the courtesy of Mr. Hammer, who handed us an advance proof. The author of this paper points out that in traction work "the best results as regards economy and regulation are obtained when the electric energy utilised has a voltage varying directly as the speed, and a current varying directly as the torque," and he claims that his new system fulfils these conditions. We may leave our readers to digest Mr. Leonard's system, which is not difficult to understand, although no diagrams are given with the paper. Our purpose is not merely to point out that the Americans are taking the lead of us, but to urge those who have charge of the design of central stations, and especially when these stations are in the hands of the local authorities, to examine into the possibility of using these as power stations for the tramway work. Bradford set the local authorities a good example in thoroughly testing the possibilities of electric lighting even whilst owning the gas works. It may be also that Bradford will do much more. It is testing the value of electric energy for tramway work, and the current is provided from the central station. Assume that, as is usual, the central station apparatus is fully loaded only two hours out of the twenty-four. Of course with accumulators it may always be worked at full load—but for the moment put the accumulators away. To get a constant full load you must supply current for something other than lighting, and at present the only other direction is for power. The use of horse power for traction work is "cruelty to animals" and a disgrace to civilisation. Electricity or something must take the place of horses, and there seems to be no real reason why central stations should not supply current for traction purposes generally. The fact of the matter is that should electricity become general for light and for power purposes, the current for both must be supplied from the same central station, otherwise we shall have two authorities, it may be two companies, or a company on the one hand and a local authority on the other, wanting to lay mains along the streets. This is a course which would tend to spoil the tempers of everybody, and the extra cost would be objectionable. When a trench is opened along a street the cost of putting in the power circuit is very little more than the cost of the conductor, but if separate trenches have to be opened, one for the light and one for the power circuit, it is easily seen that capital is saddled with an unnecessary amount. It must come to pass, then, if electricity is used, that the power be purchased from the central station. These views ought to be fully considered before complications arise and legal and parliamentary action is com-

menced. Suggestions to consider these questions in early days are always pooh-poohed. We are told to wait till the difficulties are upon us, and that publishing forebodings is opposed to the welfare of the industry. The fact is that the hindrance to progress comes from the very men who are averse to take time by the forelock. They refuse to look ahead and make arrangements to prevent future difficulties, but when the troubles arise are found busily whining and snarling at what they term the idiocy of legal restrictions. We are again told that if provision has to be made for power work, the initial cost of installation will be much heavier, and will frighten investors and local authorities. This is sheer nonsense. The only question is, can electrical energy be sold. If there is a demand for it, the initial extra cost is not worth consideration. As yet no systematic attempt has been made to endeavour to supply any demand that might be obtained. A little motor put in here and there presents no difficulty so far as its supply is concerned: it is only when provision has to be made to supply a comparatively large demand that a special power circuit is required; but it is just this large demand that is required to put a continuous full load on the machinery, and it is this continuous full load that commercial operations requires. Summed up, our text is this: The Americans have shown the practicability of electricity for traction work. Such use must ultimately come here. The supply will be from central stations, and in the design of these, provisions should be made for the probable demand. Conflicting interests will not be allowed full liberty to act on the roads and streets, and it is better to be ready with rules and regulations beforehand, rather than wait till the work is to be carried out.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ELECTRIC LOCOMOTIVES.

SIR,—In your issue of June 3 you were good enough to publish a correction of a passage in the new edition of my "Dynamo-Electric Machinery." I desire to supplement this by saying that the statement that the electric locomotives supplied by Messrs. Mather and Platt, Limited, for working the City and South London Railway "are now being replaced" by others, is not only technically inaccurate, but altogether incorrect, and to express my regret that inconvenience and annoyance should have been caused to Messrs. Mather and Platt by such a statement. I now learn from Messrs. Mather and Platt that the rolling-stock of the electric railway is about to be increased by the addition of another locomotive, which is being constructed by them.—Yours, etc.,

June 14th, 1892. SILVANUS P. THOMPSON.

DUNDEE ELECTRIC LIGHTING.

The following tenders have been accepted:

		£	s.	d.
Engines—Willans and Robinson, Limited		£3,500	0	0
Dynamos—Siemens Bros. and Co., Limited		2,632	0	0
Accumulators—The Electrical Power Storage Company, Limited		955	18	6
Mains	Feeders—Callender Bitumen, etc., Company, Limited	2,505	0	0
	Distribution—India Rubber, Gutta Percha, and Telegraph Works Company, Limited	4,445	0	0

METERS FOR RECORDING THE CONSUMPTION OF ELECTRICAL ENERGY.*

BY CHARLES HENRY WORDINGHAM, A.K.C., STUD.INST.C.E.

(Continued from page 562.)

The beautiful simplicity of the Ferranti-Wright meters, which have practically nothing to get out of order, has made them a most valuable acquisition, and they are almost exclusively used by the London Electric Supply Corporation for installations up to 40 amperes. They have proved to be reliable, and give practically no trouble as regards repairs; they are, moreover, light, compact, and easy to instal.

In the latest form of these meters it has been found possible, by great care in manufacture, to so diminish the friction as to render the shunt winding unnecessary. The field magnets consist of two vertical limbs with horizontal curved horns embracing the armature; the horns are made movable, so that their distance from the armature can be varied, and the instruments adjusted to have the same constant. They are then rendered direct-reading by proportioning the gearing. The meters are "double-sealing," and the plate protecting the terminals covers also a small screw that admits of the armature and spindle being raised from the jewel during transit, without interfering with the local authority's seal. A minor point of difference from the older type is the substitution of aluminium for mica fans. The following is a test:

TEST OF 10-AMPERE FERRANTI-WRIGHT METER.—UNSHUNTED.

Meter started with 0·4 ampere.

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
10·0	240	3·0	240
9·0	238	2·0	238
8·0	242	1·0	224
7·0	247	0·8	209
6·0	240	0·6	193
5·0	238	0·4	198
4·0	243		

The unshunted form of this meter is very suitable for recording the quantity sent out through the high-tension mains of a central station, and it has been applied to this purpose.

Shallenberger Meter.—Like the last, this is an alternate-current motor. In consists of two coils with their axes set at an angle of 45deg. to one another, both surrounding a horizontal iron disc, free to revolve on a vertical axis; the plane of the disc is at right angles to the planes of the coils. One of these coils carries the current to be measured, the other is simply closed on itself. The current in the former induces in the latter a current which is a quarter of a period behind itself, and the effect of this is that the induced current, reversing as it does with the inducing current, attracts the poles successively set up by the latter, so producing continuous rotation. The motion is retarded by aluminium fans. The following is a test of a 100-ampere meter:

TEST OF 100-AMPERE SHALLENBERGER METER.

Meter started with 3·5 amperes.

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
5	13·0	50	13·3
10	12·8	55	13·1
15	13·1	60	13·4
20	13·3	65	13·3
25	13·3	70	13·3
30	13·0	75	13·3
35	13·3	80	13·1
40	13·3	85	13·1
45	13·3	90	12·5

It will be observed that the constant is remarkably good, but the starting power is distinctly poor. A test of a smaller size is appended:

TEST OF 10-AMPERE SHALLENBERGER METER.

Meter started with 0·4 ampere.

Current in amperes.	Revolutions per B.T.U.	Current in amperes.	Revolutions per B.T.U.
0·6	17·9	5·8	18·1
1·0	17·7	7·0	18·6
1·9	18·5	8·2	17·9
2·9	18·0	9·0	17·5
3·9	18·0	10·0	17·6
4·9	17·9		

* From the *Transactions* of the Institution of Civil Engineers.

Although the above results are given in the form of a constant, the meters are direct reading, the adjustment to identical constants being effected by altering the angle between the planes of the closed and inducing coils. The latest form is arranged to be "double-sealing." This meter is very largely used in America by the Westinghouse Company, and in London by the Metropolitan Electric Supply Company. The London Electric Supply Corporation has also a few in use, with satisfactory results.

Slattery Meter.—This depends on the same principle as the Shallenberger, but differs from it in having a light copper cylinder in place of the iron disc, and in the way in which the motion of the revolving cylinder is retarded. Each vane consists of two quadrants of a circle, A B C, A D C (see Fig. 5), the lower being pivoted about the centre, A; it has attached to it an arm, E, weighed at F. When the speed increases the weight flies out and raises the quadrant A C D, which slides behind A B C, thus reducing the surface exposed to the air resistance. This is a different way of accomplishing the result obtained in the Ferranti-Wright meter by slitting the fans.

CLASS 2.

Hopkinson Meter.—One of the earliest practical forms in this class is that invented by Dr. J. Hopkinson, M.I.C.E., and, probably, if the present demand had existed at the time at which it was brought out, it would have received considerable development. This meter is shown diagrammatically in Fig. 6. A high-resistance motor, A, is placed as a shunt across the lamp heads, and is so arranged that when excited it causes a pair of governor balls, B B, to rotate; the centrifugal force of these tends to raise an iron

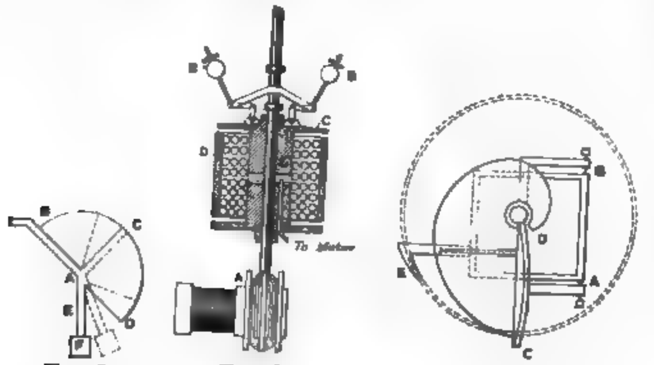

FIG. 5. FIG. 6. FIG. 7.

core, C, which is attracted downwards by the main current passing through the solenoid, D. The core carries a contact, E, which makes and breaks the motor circuit, and is so adjusted that when no current flows through the solenoid the circuit is broken. Directly a lamp is turned on, the core is attracted downwards and the motor revolves, increasing its speed until the governor balls cause its circuit to be broken. Now the centrifugal force is proportional to the square of the speed, and the attraction of the solenoid for the core is, within certain limits, proportional to the square of the current, hence these two forces will exactly balance, and the motor will revolve with a speed proportional to the current; for if it rises above the proper speed, its circuit is broken and the speed falls, and if it falls below its right value, its circuit is made and its speed increases. The number of revolutions are recorded by a trains of counting wheels driven by a worm from the motor spindle.

Frager Meter.—This is, perhaps, the most successful of this class of meter. It is an improvement on an earlier form known as the Caudray, and consists essentially of the combination of an ammeter or wattmeter, a clock and an integrating device connected to a system of counting wheels. The meter is adapted to either alternating or continuous currents—the wattmeter being always used in the former case. Its latest form may be thus described: The movable coil of the wattmeter is of German silver wire wound on a wooden bobbin, a noticeable point being that, contrary to the practice of most makers, the whole of the shunt circuit is wound inductively and is movable, instead of only a comparatively small portion being so wound and the rest of the circuit formed of a non-inductive extra resistance. The coil is suspended by a wire of phosphor bronze, and carries a long lever, formed of aluminium in the larger sizes and of brass in the smaller, balanced with a brass counterpoise so as to hang horizontally. The end of this lever is furnished on its under side with a wedge-shaped piece of steel and hangs over a horizontal cam or snail, shown in Fig. 7, which is kept in slow rotation by means of a ratchet wheel worked by a pawl from a balance wheel, maintained in oscillation by a shunt current. The snail is carried by a cradle, hinged at A B (Fig. 7), and pressed upwards by a spring. Rigidly attached to the spindle carrying the snail-cradle, and running along the straight edge of the snail and projecting beyond it, is a piece of steel, C D, bevelled on its edge, which is circular, having the suspension wire for centre. As the spindle rotates, this bevelled edge comes in contact with the steel wedge on the lever, and causes the latter to rise and to jam against a brass sector placed over it. If no current passes through the main coil of the wattmeter, the lever stands at zero, and, as rotation proceeds, it simply drops off the piece C D. If, however, the lever is deflected when the engagement takes place, the lever drops on to the snail, depresses it, and causes a pawl, E, which it carries to engage with a ratchet wheel, which ratchet wheel drives a counting train. Rotation goes on, and, as long as the lever remains on the snail, it is locked, and the counting wheels continue to register. As soon as the lever reaches the round edge of the snail it drops off, the snail rises, and the pawl ceases to drive the counting train. Now, an inspection of the snail will show that its shape is such that the greater the deflection of the lever at the instant of its engagement, the longer it remains on the snail, and that it must drop off once every revolution. The action of the instrument is, therefore this: at equal intervals of time, this interval being the time taken by

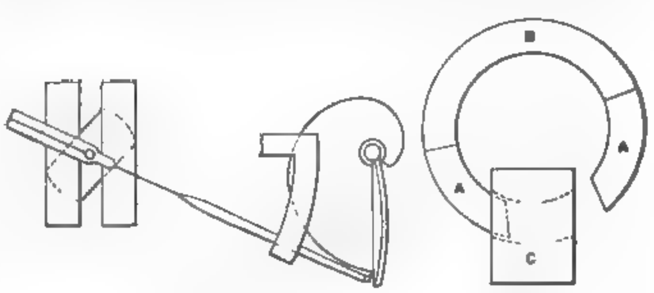

FIG. 8. FIG. 9.

one complete revolution of the snail (200, 300, or 400 seconds, according to the size of the meter) the lever is locked in the position which it happens to occupy at the instant, remains on the snail for a time proportional to its deflection, and then quits it, having caused a certain amount to be registered on the dials. Now, this amount is that which would have been used in the time occupied by one revolution of the snail, if the current had retained the value it had when the lever engaged. If the current changes, no account is taken of the alteration until the next time the lever engages, when the current is again assumed to remain constant during one revolution. What the instrument does, then, is to take a reading of the wattmeter so many times an hour, to multiply each reading by the time of one revolution, and to add all these successive products together on the dials.

The following are details of the several parts: The balance wheel is furnished with a flat chronometer spring, and consists of a nearly complete circle, formed of two pieces of soft iron, A A (Fig. 9), united by a brass piece, B. A short solenoid, C, excited by a shunt current, is so placed that when the wheel is at rest the soft iron cores are unsymmetrically placed. At the top of the spindle carrying this wheel is the contact-making device shown in Fig. 10. Two little steel plates, one above the other, shaped as shown, are mounted loose on the spindle; the top one has a V-shaped slot, A, in which works a pin, B, attached to the spindle, C, from which it derives an oscillating motion; the lower plate has a much wider V-shaped groove, shown dotted, and in this works a pin projecting downwards from the upper plate. Each plate has a depression, shown at D, and a knife-edge, E, fixed to a spring, F, one end of which can make contact with a contact screw, G, bears against

the plates. When the depressions in the two plates are opposite the knife-edge it drops in, and contact is made at G, completing the circuit through the solenoid. If the amplitude of vibration is small, the depressions in the two plates correspond; but if it becomes large, the lower plate is carried round by the upper one, and left so that it prevents the knife-edge from falling. When the amplitude diminishes, contact is again made and a fresh impulse given.

The counting gear is connected to the snail-spindle by means of a pair of bevel wheels, and by adjusting the number of teeth in them, the meters are made to indicate the Board of Trade units on the dials, however much the constants of the wattmeter may vary.

This meter is certainly ingenious, but evidently highly complicated. When carefully adjusted and protected from vibration, it is capable of giving accurate results with a steady current; but under the conditions of actual practice it labours under disadvantages, among which may be mentioned: (1) The necessity for careful levelling and adjusting *in situ*, thus making it uncertain whether the test made before it is sent out will apply when it is installed in the consumer's house. (2) So many working parts are liable to get out of order. (3) In cases where the amount of light used is constantly varying at short intervals of time, as in a theatre, indications far from the truth may be given. Small variations in current, due to unsteady running, will cause the lever to oscillate, and it may therefore become locked at the wrong point.

Richard Frères Meter.—Like the Frager, this in an intermittent watt-hour meter; but it has this important advantage—its readings are separated by intervals of only 15 seconds. It comprises a clock, wound electrically four times a minute, a wattmeter, and a train of counting wheels. The following cycle of operations is gone through every 15 seconds. At a given instant a shunt circuit is made through an electromagnet, the armature of which is

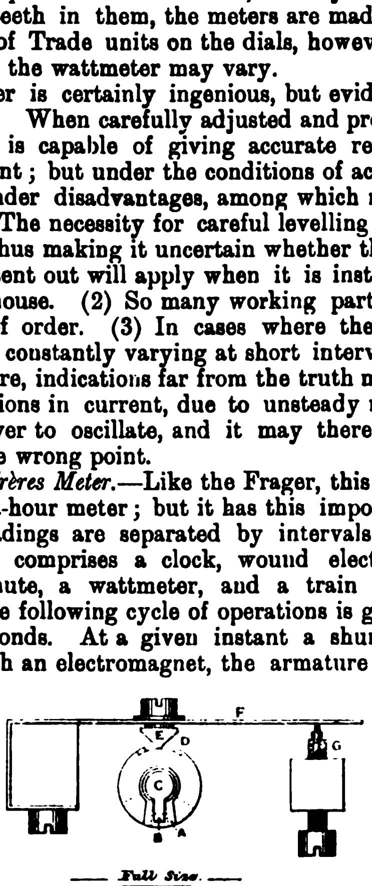

FIG. 10.

attracted and winds the clock, the circuit being immediately broken again. After 10 seconds another shunt circuit is closed, causing a current to flow through the movable fine wire coil of the wattmeter and through an electromagnet actuating a friction clutch. This clutch, under normal conditions, mechanically connects the movable coil with the counting train, but when pulled back it allows the coil to move without affecting the train. When the contact is made the clutch moves first, its moment of inertia being much less than that of the wattmeter; the coil then deflects, a dash-pot steadying it quickly; the current flows for five seconds and is then interrupted, the clutch flies back by means of a spring, and the wattmeter returns to zero, carrying with it the first wheel of the train through an angle corresponding to its deflection. The clock-winding contact is again made, and the same series of operations gone through as before.

This meter is in use in France, but has only recently been introduced into England; it is at present only used for continuous currents, but will doubtless soon be applied to alternating currents also. The author has had no experience of the meter, but the number of contacts and the complication of its parts will probably be found serious drawbacks.*

CLASS 3.

The majority of the meters in this class are founded on Prof. Ayrton's ergmeter, which consisted of two clocks regulated to keep exactly the same time. One of these had a magnet in the place of a bob at the end of the pendulum, and beneath it was placed a coil carrying the current to be measured; the magnet being attracted by the coil when the current flowed through it, the pendulum was accelerated, and the clock gained. The difference in time of the two clocks was thus a measure of the quantity of electricity that had passed. There have been numerous improvements on the original idea, the chief being embodied in the Aron and Oulton-Edmundson meters.

Aron Meter.—In this the two clocks are enclosed in one case, and their wheel-trains are connected to a differential gear, consisting of two bevel wheels, one driven by each clock. Between these, and gearing into both, is a bevel wheel free to revolve at one end of a spindle, the other end of which carries a counterpoise; to the middle point of this spindle, and at right angles to it, is rigidly fixed a second spindle connected to a counting train. If the large bevel wheels both revolve at the same speed, the intermediate wheel simply revolves on its axis; but if one goes faster than the other, the intermediate wheel, in addition to revolving, rolls on the large wheels by an amount depending on their difference in speed, and in so doing twists the counting spindle.

This meter is made in two forms—viz., (1) that just described in which the pendulum carries a magnet: this is adapted to measure continuous currents only, and is a current integrator; (2) that in which the magnet is replaced by a fine wire coil oscillating inside a solenoid: this is adapted to either continuous or alternate currents, and is a watt-hour integrator. The former is in very extensive use, and all employing it speak highly of its performance. It is open to the objection already referred to in connection with the Frager meter, that it has to be adjusted *in sitù*, for it is a fact well known to clockmakers that a clock once shifted always requires regulating, no matter how carefully it may have been moved. The permanent magnet is liable to change, and it is found necessary to redetermine the constant of a meter that has been in a house where a short circuit has occurred, the magnet being weakened by the excessive current. The clocks have to be wound up at least once a month, and if one of them by any mishap should stop, the whole record is destroyed. It is the practice in some central stations to synchronise the meters every three months; it is then found that about half are slow and half fast, but the error is not serious. An evidence of accuracy is afforded by a meter at the station agreeing with the sum of the readings of the consumer's meters within, it is stated, a small percentage.*

The second form is seldom used except for alternating currents, and with these it is extremely difficult to get an accurate test in the lower part of the scale, on account of the great length of time required in order to get a reading and the necessity for having the pressure and current observed during the whole run, since it cannot be relied on to remain steady, as in the case of continuous current where cells can be used. The following is a test of the higher part of the scale of this type:

TEST OF 200-AMPERE ALTERNATE-CURRENT ARON METER.

Current in amperes.	Pressure in volts.	Board of Trade units per division.
200·1	100	1·071
190·2	100	1·081
180·0	100	1·075
171·0	100	1·101
159·7	100	1·063
150·0	100	1·068
140·3	100	1·065
130·0	100	1·066
120·0	100	1·070
110·3	100	1·055
100·0	100	1·057
90·3	100	1·056
80·0	100	1·102
70·0	100	1·083
60·0	100	1·068

The meters are now made direct-reading, and are provided with an attachment for keeping the clocks in synchronism when no current is on, the difficulty in ensuring this being the chief objection to the meter. It is extremely

* This instrument must not be confounded with the Richard Frères recording ammeter, which is a very satisfactory piece of apparatus for a different purpose, and hardly comes within the scope of this paper.

* Since this paper was read, the author has been favoured by Mr. J. H. Tonge, Stud.Inst.C.E., with the following test of a 100-ampere continuous-current Aron meter. The instrument read ½ per cent. low with 100 amperes, with 50 amperes, and with 20 amperes, and 10 per cent. low with one ampere. In 48 hours the difference in time between the two pendulums was one complete period.

simple, consisting merely of a light, very slack thread joining the two pendulums and having a small weight hung at its middle point. It effects its object perfectly, but it would appear probable that the constant at low readings would be altered. The author has not yet tried whether this is the case or not.

(To be continued.)

SOME POINTS CONNECTED WITH THE ELECTROMOTIVE FORCE OF SECONDARY BATTERIES.*

BY J. H. GLADSTONE, PH.D., AND W. HIBBERT, F.I.C.

Last month we communicated a paper to the Institute of Electrical Engineers "On the Cause of the Changes of Electromotive Force in Secondary Batteries," which gave rise to a certain amount of discussion. Since then we have received a paper by M. Darrieus entitled, "Essai de théorie chimique sur les accumulateurs Electriques au plomb," which was read before the Société Internationale des Electriciens on May 4. In it he agrees with Prof. Armstrong and Mr. Robertson in attributing the large initial E.M.F. to persulphuric acid; and he opposes what he terms the most generally admitted theory of the production of sulphate during discharge, so far as the positive plate is concerned.

In our recent paper we had assumed the truth of the view put forth by Messrs. Gladstone and Tribe in 1882, that in discharge "sulphate of lead is the ultimate product on both plates," and on discharging again "this lead sulphate is oxidated on the one plate and reduced on the other." This conclusion was not received at first without powerful opposition; but it has won its way to general acceptance among workers on the subject. Among these may be specially mentioned Prof. Frankland, Mr. Swinburne, M. Reynier, Messrs. Kohlrausch and Heine, Prof. Ayrton and his colleagues, and Mr. G. H. Robertson.

We can only attribute the finding by M. Darrieus of a large amount of oxide of lead mixed with sulphate on the positive plate to the fact of the difficulties of analysis, as it is hard to imagine that oxide of lead could remain as such when surrounded by sulphuric acid.

The reaction which takes place in discharging was expressed in our recent paper by the general equation

$$PbO_2 + H_2SO_4 \ldots H_2SO_4 + Pb = PbSO_4 + H_2O \ldots H_2O + PbSO_4$$

and the reaction that takes place on charging was expressed by the same equation reversed. It is to be understood that these equations represent the initial and the ultimate products, and take no note of any intermediate reaction. There have been numerous theories in regard to such intermediate changes, but on these we must be held at present to express no opinion.

It is evident that if the reaction consists in the alternate formation and reduction of $PbSO_4$ there must be great changes in the strength of the sulphuric acid within the pores of each plate. How these changes must be affected, not only the electrolytic reation, but by the influence of gravitation and of diffusion, by electrical transference, by local action, etc., is traced out in our paper. At the same time, continuing the experiments which were communicated to this society in 1890, we have not merely satisfied ourselves more fully that a change of strength of acid against the working surfaces of the plates results in a change of E.M.F., but we have determined the amount quantitatively for all strengths of acid, from a mere trace to 99 per cent.

We show that the changes of E.M.F. in charge and discharge coincide fairly well with the changes of strength of acid deduced *à priori*. For this purpose we employed the determinations lately published by Prof. Ayrton and his colleagues, believing them to be the best. Our conclusion is "that the changes of E.M.F. in a secondary battery depend on the strength of the acid that is against the working surfaces of the plates."

The only serious opponents of our views, so far as we know, are Messrs. Armstrong and Robertson. They have attributed the changes of E.M.F. to the persulphuric acid and hydrogen dioxide which are produced during the change. The experimental grounds of this conclusion are not yet fully published, but we are able to refer to their remarks in the discussion of our paper, as printed in the *Electrician* of last Saturday. They commence by substituting for our general equation a complicated and unsymmetrical one, which at best can only be one form of it, and cannot represent those of our experiments that were made with the strongest sulphuric acid. Their subsequent remarks are addressed mainly to the supposed contamination of our sulphuric acid with the soluble peroxides, and to the probability of H_2SO_4 itself taking part in the reaction. Now, as to the first objection:

Supposing that our plates in the first instance were not washed perfectly clean, there can be no reason why the trace of peroxide should always vary in amount with the strength of the fresh sulphuric acid in which the plates are dipped. As to the second objection, we have not, as supposed, speculated on hydrates of sulphuric acid in solution, and have expressly stated that we "content ourselves at present with pointing out that the liquid in the secondary cell is a mixture, or a chemical compound, of two different liquids, sulphuric acid (H_2SO_4) and water, in varying proportions."

The most tangible criticism is directed not against our main experiments and argument, which are untouched, but against one of our confirmatory experiments. Messrs. Armstrong and Robertson say, "Two series of experiments were described by the authors, in which the E.M.F. developed, on the one hand, between two lead plates, and, on the other, between two peroxide plates in acids of different strengths was measured. They appeared to regard these results as very important, as they went so far as to draw conclusions from a curve obtained by integrating the two sets of observations." They might have added that this curve coincides both in shape and magnitude with that previously determined, when a Pb and PbO_2 plate were placed together in different strengths of acid. They attribute the results obtained with the two peroxide plates to the lead supports because "local action would set in and be at a maximum in the stronger acid, and therefore the lead plate of this couple would be more protected, and the support opposite would be more active against the peroxide of this plate." The explanation is ingenious, and we might welcome it, since it presupposes the truth of our own conclusion, that with a stronger sulphuric acid there is greater electrolytic action. It is, indeed, not impossible that the lead support may in some cases have a small influence on the result, but it is inconceivable that such large and uniform differences and such close coincidences as those shown in our paper could be due to the accidental operations of local action. In this connection they claim support from an experiment of ours with a plate dried at 100 per cent., but a reference to Table 5 will show that in that experiment of ours we obtained, not the highest, but really the lowest readings.

In order to show that the increase of E.M.F. does not depend upon the presence or absence of persulphuric acid, we have within the last few days instituted the following two additional experiments: 1. A Pb plate and a PbO_2 plate, perfectly free from dissolved oxides, were placed in pure sulphuric acid of 12 per cent. strength, a porous diaphragm being between the two. The E.M.F. was 1·945. Into the acid surrounding the PbO_2 plate was placed 1 per cent. of persulphate of potassium; the E.M.F. remained at 1·945. The lead plate was then brought into the same compartment so that both were exposed to the influence of persulphuric acid. The E.M.F. was scarcely changed—viz., 1·934.

2. A secondary battery was made with phosphoric acid instead of sulphuric acid. Observations were made with different strengths of this phosphoric acid, varying in specific gravity from 1·05 to 1·5. The E.M.F. increased with the strength of the acid; and in the full range there was a difference of 0·176 volt. The theoretical variation calculated by Lord Kelvin's thermo-chemical law from the known heat of dilution would be about 0·170 volt. Of course, there was no persulphuric acid, and we cannot assume the presence of any higher acid oxide of phosphorus corresponding to it, as such a compound is not known.

We have investigated the effect of charging and repose on the E.M.F. of a small accumulator with phosphoric acid as the electrolyte, and found the results quite analogous to

* Paper read before the Physical Society.

those obtained with sulphuric acid, as described in our paper read at this society in 1890, when we first announced our view that "the abnormal amount of E.M.F. is due to the inequality of acid strength, and its gradual disappearance to equalisation of strength produced by diffusion."

ON THE MEASUREMENT OF THE MAGNETIC PROPERTIES OF IRON.*

BY THOMAS GRAY, B.SC., F.R.S.E.

This paper gives the method of experiment and results obtained in some investigations on the time-rate of rise of current in a circuit having large electromagnetic inertia. The experiments were made on a circuit containing the coils of a large electromagnet having laminated cores and pole-pieces. The mean length of the iron circuit was about 250 cm., and its cross-section 320 sq. cm. The magnetising coil had 3,840 turns, when all joined in series, and a resistance of 10·4 ohms. The coils were so arranged that they could be joined in a variety of ways so as to vary the resistance, inductive coefficient, etc., and also to allow the magnet to be used either as an open or a closed-circuit transformer. The E.M.F. used in the experiments was obtained from a storage battery, and the method of experiment was to trace the curve, giving the relation of current to time, on a chronograph sheet.

One set of experiments shows the effect of varying the impressed E.M.F. on the time required for the current to attain any given percentage of its maximum strength. The results show that for any particular percentage there is always a particular E.M.F. which takes maximum time. Thus for the circuit under consideration, and with successive repetitions of the current in the same direction, it takes longer time for the current produced by an impressed E.M.F. of four volts to reach 95 per cent. of its maximum than it takes for the current produced by either three or five volts to reach 95 per cent. of their maximum. The results show also that within considerable limits, the time required for the current to become uniform is on the whole nearly inversely proportional to the impressed E.M.F., and that for moderate values of the E.M.F. the time may be very great. When the E.M.F. was two volts, and the current sent in such a direction as to reverse the magnetism left in the magnet by a previous current of the same strength, the time required for the current to establish itself was over three minutes. The difference of time required for repetition and for reversal of previous magnetisation was also very marked when the iron circuit was closed. The results show that great errors may arise by the use of ballistic methods of experiment, especially when weak currents are used, and that for testing resistances of circuits containing electromagnets a saving of time may be obtained by using a battery of considerable E.M.F.

Another set of experiments gives the effect of successive reversals of the impressed E.M.F. at sufficient intervals apart to allow the magnetisation to be established in each direction before reversal began. In this set also the effect of cutting out the battery and leaving the magnet circuit closed is illustrated, showing that several minutes may be required for the magnet to lose its magnetism by dissipation of energy in the magnetising coil. The effect on these cycles of leaving an air space in the iron circuit is also illustrated. It is shown that a comparatively small air space nearly eliminates the residual magnetism and diminishes considerably the rate of variation of the coefficient of induction and the dissipation of energy in the magnet.

Several cycles are shown for the magnet used as a transformer with different loads on the secondary. The results give evidence that there is less energy dissipated in the iron the greater the load on the secondary of the transformer.

Some experiments are also quoted which go to show that the dissipation of energy due to magnetic retentiveness (magnetic hysteresis) is simply proportional to the total induction produced when the measurements are made by kinetic methods. Reference is made to the recent experiments of Alexander Siemens and others which seem to confirm this view.

* Paper read before the Royal Society.

ELECTRIC LIGHTING IN DUBLIN.

The following are the total tenders received on the 10th ult., for the wiring of the civic buildings in Dublin. The work was divided into four sections, and contractors were asked to tender for each section separately, and for the lot:

J. G. Statter and Co.	£1,220	0	0
Edmundson Limited (accepted)	1,298	15	0
Fowler, Lancaster, and Co.	1,500	0	0
T. Scott Anderson	1,554	0	0
Laing, Wharton, and Down	1,644	0	0
Rashleigh Phipps and Dawson	1,649	0	0
Croggon and Co.	1,650	0	0
John Pearce	1,838	0	0
J. K. Fahie and Son	2,000	0	0
Electrical Engineering Company of Ireland	2,458	10	5
Berry, Harrison, and Co.	2,504	10	0

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Continued from page 569.)

When the highest vacuum obtainable with the pump had been reached, the potash bulb was usually wrapped with cotton which was sprinkled with ether so as to keep the potash at a very low temperature, then the reservoir R_2 was lowered, and upon reservoir R_1 being emptied the receiver, r, was quickly sealed up. When a new bulb was put on, the mercury was always raised above stop-cock C_1, which was closed, so as to always keep the mercury and both the reservoirs in fine condition, and the mercury was never withdrawn from R_1 except when the pump had reached the highest degree of exhaustion. It is necessary to observe this rule if it is desired to use the apparatus to advantage. By means of this arrangement I was able to proceed very quickly, and when the apparatus was in perfect order it was possible to reach the phosphorescent stage in a small bulb in less than 15 minutes, which is certainly very quick work for a small laboratory arrangement requiring in all about 100lb. of mercury. With ordinary small bulbs the ratio of the capacity of the pump, receiver, and connections, and that of reservoir, R, was about 1 : 20, and the degrees of exhaustion reached were necessarily very high, though I am unable to make a precise and reliable statement how far the exhaustion was carried.

What impresses the investigator most in the course of these experiences is the behaviour of gases when subjected to great rapidly-alternating electrostatic stresses. But he must remain in doubt as to whether the effects observed are due wholly to the molecules, or atoms, of the gas which chemical analysis discloses to us, or whether there enters into play another medium of a gaseous nature, comprising atoms, or molecules, immersed in a fluid pervading the space. Such a medium surely must exist, and I am convinced that, for instance, even if air were absent, the surface and neighbourhood of a body in space would be heated by rapidly alternating the potential of the body; but no such heating of the surface or neighbourhood could occur if all free atoms were removed and only a homogeneous, incompressible, and elastic fluid—such as ether is supposed to be—would remain, for then there would be no impacts, no collisions. In such a case, as far as the body itself is concerned, only frictional losses in the inside could occur.

It is a striking fact that the discharge through a gas is established with ever-increasing freedom as the frequency of the impulses is augmented. It behaves in this respect quite contrarily to a metallic conductor. In the latter the impedance enters prominently into play as the frequency is increased, but the gas acts much like a series of condensers would; the facility with which the discharge passes through seem to depend on the rate of change of potential. If it act so, then in a vacuum tube even of great length, and no matter how strong the current, self-induction could not assert itself to any appreciable degree. We have, then, as far as we can now see, in the gas a conductor which is capable of transmitting electric impulses of any frequency which we may be able to produce. Could the frequency be brought high enough, then a queer system of electric distribution which would be likely to interest gas companies, might be realised; metal pipes filled with gas—the metal being the insulator, the gas the conductor—supplying phosphorescent bulbs, or, perhaps, devices as yet uninvented. It is certainly possible to take a hollow tore of copper, rarefy the gas in the same, and by passing impulses of sufficiently high frequency through a circuit around it, bring the gas inside to a high degree of incandescence; but as to the nature of the forces there would be considerable uncertainty, for it would be doubtful whether with such impulses the copper tore would act as a static screen. Such paradoxes and apparent impossibilities we encounter at every step in this line of work, and therein lies, to a great extent, the charm of the study.

I have here a short and wide tube which is exhausted to a high degree and covered with a substantial coating of bronze, the

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

coating allowing barely the light to shine through. A metallic clasp, with a hook for suspending the tube, is fastened around the middle portion of the latter, the clasp being in contact with the bronze coating. I now want to light the gas inside by suspending the tube on a wire connected to the coil. Anyone who would try the experiment for the first time, not having any previous experience, would probably take care to be quite alone when making the trial, for fear that he might become the joke of his assistants. Still, the bulb lights in spite of the metal coating, and the light can be distinctly perceived through the latter. A long tube covered with aluminium bronze lights when held in one hand—the other touching the terminal of the coil—quite powerfully. It might be objected that the coatings are not sufficiently conducting; still, even if they were highly resistant, they ought to screen the gas. They certainly screen it perfectly in a condition of rest, but not by far perfectly when the charge is surging in the coating. But the loss of energy which occurs within the tube, notwithstanding the screen, is occasioned principally by the presence of the gas. Were we to take a large hollow metallic sphere and fill it with a perfect incompressible fluid dielectric, there would be no loss inside of the sphere, and consequently the inside might be considered as perfectly screened, though the potential be very rapidly alternating. Even were the sphere filled with oil, the loss would be incomparably smaller than when the fluid is replaced by a gas, for in the latter case the force produces displacements; that means impact and collisions in the inside.

No matter what the pressure of the gas may be, it becomes an important factor in the heating of a conductor when the electric density is great and the frequency very high. That in the heating of conductors by lightning discharges air is an element of great importance, is almost as certain as an experimental fact. I may illustrate the action of the air by the

FIG. 31.—Bulb showing Radiant Lime Stream at Low Exhaustion.

following experiment: I take a short tube which is exhausted to a moderate degree, and has a platinum wire running through the middle from one end to the other. I pass a steady or low-frequency current through the wire, and it is heated uniformly in all parts. The heating here is due to conduction, or frictional losses, and the gas around the wire has, as far as we can see, no function to perform. But now let me pass sudden discharges, or a high-frequency current, through the wire. Again the wire is heated, this time principally on the ends and least in the middle portion; and if the frequency of the impulses, or the rate of change, is high enough, the wire might as well be cut in the middle as not, for practically all the heating is due to the rarefied gas. Here the gas might only act as a conductor of no impedance diverting the current from the wire as the impedance of the latter is enormously increased, and merely heating the ends of the wire by reason of their resistance to the passage of the discharge. But it is not at all necessary that the gas in the tube should be conducting; it might be at an extremely low pressure, still the ends of the wires would be heated—as, however, is ascertained by experience—only the two ends would in such case not be electrically connected through the gaseous medium. Now what with these frequencies and potentials occurs in an exhausted tube occurs in the lightning discharges at ordinary pressure. We only need remember one of the facts arrived at in the course of these investigations—namely, that to impulses of very high frequency the gas at ordinary pressure behaves in much the same manner as though it were at moderately low pressure. I think that in lightning discharges frequently wires or conducting objects are volatilised merely because air is present, and that, were the conductor immersed in an insulating liquid, it would be safe, for then the energy would have to spend itself somewhere else. From the behaviour of gases to sudden impulses of high potential, I am led to conclude that there can be no surer way of diverting a lightning discharge than by affording it a passage through a volume of gas, if such a thing can be done in a practical manner.

There are two more features upon which I think it necessary to dwell in connection with these experiments—the "radiant state" and the "non-striking vacuum." Anyone who has studied Crooke's work must have received the impression that the "radiant state" is a property of the gas inseparably connected with an extremely high degree of exhaustion. But it should be remembered that the phenomena observed in an exhausted vessel are limited to the character and capacity of the apparatus which is made use of. I think that in a bulb a molecule, or atom, does not precisely move in a straight line because it meets no obstacle, but because the velocity imparted to it is sufficient to propel it in a sensibly straight line. The mean free path is one thing, but the velocity—the energy associated with the moving body—is another, and under ordinary circumstances I believe that it is a mere question of potential, or speed. A disruptive discharge coil, when the potential is pushed very far, excites phosphorescence and projects shadows, at comparatively low degrees of exhaustion. In a lightning discharge matter moves in straight lines at ordinary pressure when the free mean path is exceedingly small, and frequently images of wires or other metallic objects have been produced by the particles thrown off in straight lines. I have prepared a bulb to illustrate by an experiment the correctness of these assertions. In a globe, L, Fig. 31, I have mounted upon a lamp filament, *f*, a piece of lime, *l*. The lamp filament is connected with a wire which leads into the bulb, and the general construction of the latter is as indicated in Fig. 19, before described.

FIG. 32.—Electro-dynamic Induction Lamp.

FIG. 33.—Electro-dynamic Induction Tube.

The bulb being suspended from a wire connected to the terminal of the coil, and the latter being set to work, the lime piece, *l*, and the projecting parts of the filament, *f*, are bombarded. The degree of exhaustion is just such that with the potential the coil is capable of giving phosphorescence of the glass is produced, but disappears as soon as the vacuum is impaired. The lime containing moisture, and moisture being given off as soon as heating occurs, the phosphorescence lasts only for a few moments. When the lime has been sufficiently heated, enough moisture has been given off to impair materially the vacuum of the bulb. As the bombardment goes on, one point of the lime piece is more heated than other points, and the result is that finally practically all the discharge passes through that point which is intensely heated, and a white stream of lime particles, Fig. 31, then breaks forth from that point. This stream is composed of "radiant" matter, yet the degree of exhaustion is low. But the particles move in straight lines, because the velocity imparted to them is great, and this is due to three causes—to the great electric density, the high temperature of the small point, and the fact that the particles of the lime are easily torn and thrown off—far more easily than those of carbon. With frequencies such as we are able to obtain, the particles are bodily thrown off and projected to a considerable distance; but with sufficiently high frequencies no such thing would occur. In such case only a stress would spread, or a vibration would be propagated through the bulb. It would be out of question to reach any such frequency on the assumption that the atoms move with the speed of light; but I believe that such a thing is impossible. For this an enormous potential would be required. With potentials which we are able to obtain, even with a disruptive discharge coil, the speed must be quite insignificant.

As to the "non-striking vacuum," the point to be noted is that it can occur only with low-frequency impulses, and it is necessitated by the impossibility of carrying off enough energy with such impulses in high vacuum, since the few atoms which are around the terminal, upon coming in contact with the same are repelled and kept at a distance for a comparatively long period

of time, and not enough work can be performed as to render the effect perceptible to the eye. If the difference of potential between the terminals is raised, the dielectric breaks down. But with very high frequency impulses there is no necessity for such breaking down, since any amount of work can be performed by continually agitating the atoms in the exhausted vessel, provided the frequency is high enough. It is easy to reach—even with frequencies obtained from an alternator as here used—a stage at which the discharge does not pass between two electrodes in a narrow tube, each of these being connected to one of the terminals of the coil, but it is difficult to reach a point at which a luminous discharge would not occur around each electrode.

A thought which naturally presents itself in connection with high-frequency currents is, to make use of their powerful electrodynamic inductive action to produce light effects in a sealed glass globe. The leading-in wire is one of the defects of the present incandescent lamp, and if no other improvement were made, that imperfection at least should be done away with. Following this thought, I have carried on experiments in various directions, of which some were indicated in my former paper. I may here mention one or two more lines of experiment which have been followed up. Many bulbs were constructed, as shown in Fig. 32 and Fig. 33. In Fig. 32 a wide tube, T, was sealed to a smaller W-shaped tube, U, of phosphorescent glass. In the tube T was placed a coil, C, of aluminium wire, the ends of which were provided with small spheres, t and t_1, of aluminium, and reached into the U-tube. The tube T was slipped into a socket containing a primary coil through which usually the discharges of Leyden jars were directed, and the rarefied gas in the small U-tube was excited to strong luminosity by the high-tension currents induced in the coil C. When Leyden jar discharges were used to induce currents in the coil C, it was found necessary to pack the tube T tightly with insulating powder, as a discharge would occur frequently between the turns of the coil, especially when the primary was thick and the air gap, through which the jars discharged, large, and no little trouble was experienced in this way. In Fig. 33 is illustrated another form of the bulb constructed. In this case a tube, T, is sealed to a globe, L. The tube contains a coil, C, the ends of which pass through two small glass tubes, t and t_1, which are sealed to the tube T. Two refractory buttons, m and m_1, are mounted on lamp filaments which are fastened to the ends of the wires passing through the glass tubes t and t_1. Generally in bulbs made on this plan the globe L communicated with the tube T. For this purpose the ends of the small tubes, t and t_1, were just a trifle heated in the burner, merely to hold the wires, but not to interfere with the communication. The tube T, with the small tubes, wires through the same, and the refractory buttons, m and m_1, was first prepared, and then sealed to globe L, whereupon the coil C was slipped in and the connections made to its ends. The tube was then packed with insulating powder, jamming the latter as tight as possible up to very nearly the end, then it was closed and only a small hole left through which the remainder of the powder was introduced, and finally the end of the tube was closed. Usually in bulbs constructed as shown in Fig. 33, an aluminium tube, a, was fastened to the upper end, s, of each of the tubes t and t_1, in order to protect that end against the heat. The buttons, m and m_1, could be brought to any degree of incandescence by passing the discharges of Leyden jars around the coil C. In such bulbs with two buttons a very curious effect is produced by the formation of the shadows of each of the two buttons.

(To be continued.)

PHYSICAL SOCIETY.—June 10, 1892.

Mr. WALTER BAILY, M.A., vice-president, in the chair.

A paper "**On Some Points connected with the E.M.F. of Secondary Batteries,**" by **Dr. Gladstone** and **Mr. W. Hibbert**, was read by the former. The communication is given in full elsewhere in this issue.

Prof. Ayrton thought that there was no question that the strength of acid had much to do with the changes of E.M F. The point at issue, he considered, was whether the changes were direct effects of the strength of acid, or due to secondary actions brought about by alterations in strength.

Mr. E. W. Smith said Mr. Robertson and himself were repeating the author's experiments with two PbO_2 plates without any grid. They had obtained results analogous to those mentioned in the paper, but the true explanation of the effects was still to seek.

Mr. W. Hibbert contended that the soluble oxides referred to by Prof. Armstrong and Mr. Robertson were not present in their experiments. They had also proved that changes in acid strength altered the E.M.F., whilst presence of persulphuric acid did not.

Dr. Gladstone, in reply, said they also were making experiments without grids, but had not made sufficient progress to discuss them at present. Mr. Hibbert and himself believed the effects of local action inconsiderable, whilst Messrs. Armstrong and Robertson thought them very important. He hoped that ere long the points would be settled conclusively.

A paper on "**Workshop Ballistic and other Shielded Galvanometers,**" by **Prof. W. E. Ayrton, F.R.S.**, and **Mr. T. Mather**, was read by Prof. Ayrton. The galvanometers described were of the type having movable coils and fixed magnets, the advantages of which are well known. In designing the ballistic instruments their aim had been to obtain sensibility and portability, combined with being screened from external influences, for it was often desirable to measure the magnetic fluxes and fields in dynamos by apparatus near the machines. One of the improvements adopted was the narrow coil, described in a paper "On the Shape of Movable Coils, etc.," read before the society in 1890. Such coils are particularly advantageous for ballistic instruments, for not only can greater swings be obtained by the discharge of a given quantity of electricity through such a coil than with ordinary-shaped coils when the periodic times are the same, but even when the same control is used, the same length of wire in the coil, and suspended in the same field, the narrow coil is more sensitive to discharges than coils of any other shape. Another improvement was the use of phosphor bronze strip for the suspensions instead of round wire. For a given tensile strength, both the control and the sub-permanent set could be diminished by using strip. In Feb., 1888, the authors made a d'Arsonval of the ordinary type as a ballistic instrument, and found that although it was suitable for comparing condensers, yet for induction measurements the damping was excessive unless the resistance in the circuit was very large. This greatly reduced the sensitiveness. In 1890 they tried one of Carpentier's milliampere-meters as a ballistic instrument, but found it insensitive. A narrow-coil instrument made in the same year was found to be sensitive for currents, but as the coil was wound on copper to get damping, it was not suitable for ballistic work. In January, 1892, a somewhat similar instrument was constructed for ballistic purposes, and was found very sensitive and convenient. Although the coil had only a resistance of 13 ohms, one microcoulomb gave a swing of 170 divisions on a scale 2,000 divisions distant, the periodic time being 2·7 seconds. The instrument could be used near electromagnets or dynamos, and was so sensitive that for ordinary induction measurements very large resistances can be put in series with it, thus reducing the damping to a very small amount. On the other hand, the coil could be brought to rest immediately by a short-circuit key. It had the further advantage that it was not necessary to redetermine its constant every time it was used. The chief disadvantage of such instruments was the variable damping, on closed circuits, of different resistances. This could, however, be overcome by arranging shunts and resistances so that the external resistance between the galvanometer terminals was the same for all sensibilities. A portable ballistic instrument intended for workshop use was next described. This had a narrow coil and a pointer moving over a dial whose whole circumference was divided into 200 parts. The instrument had been designed to give a complete revolution for a reversal of a flux of two million C.G.S. lines, but the pointer could turn through two or more revolutions. To test stray fields a test coil with a total area of 10,000 square centimetres is used, and has a trigger arrangement for suddenly twisting it through two right angles. The instrument then reads off directly the strength of field in C.G.S. lines. To vary the sensitiveness in known proportions, resistances are employed. Referring to the improvements made in movable-coil instruments since January, 1890, when a paper on "Galvanometers" was read before the society by Dr. Sumpner and the present authors, Prof. Ayrton said Mr. Crompton had greatly increased the sensitiveness of Carpentier's instruments by suspending the coils with phosphor bronze strip. Mr. Paul had brought out a narrow-coil instrument which combined the advantages of portability, dead beatness, quickness, and sensibility. Specimens of these instruments were exhibited. The narrow coils are enclosed in silver tubes which serve to damp the oscillations. Such a coil is suspended within a brass tube, which also forms the mirror chamber, and slides down between the poles of a circular magnet fixed to the base. To clamp the coil, a plug mounted on a slotted spring passes through a hole in the brass tube. A tube can be taken out and replaced by another containing a coil of different resistance in a few seconds. An instrument of this kind with a coil of 300 ohms gave 95 divisions per micro-ampere, and the damping on open circuit was such that any swing was $\frac{1}{18}$ of the previous one. On comparing recent instruments with those mentioned in the paper on galvanometers above referred to, a distinct improvement is apparent, for their sensitiveness is, for the same resistance and periodic time, as great as that of Thomson instruments.

Prof. Perry remarked that the forces dealt with were extremely small.

Mr. Swinburne thought that ballistic galvanometers might be regarded as instruments indicating the time-integral of E.M.F. rather than quantity. Illustrating his meaning by reference to dynamos, he said that if two machines arranged as dynamo and motor were joined by wires, then if the armature of the dynamo were turned through any angle, that of the motor would move through the same angle supposing friction eliminated. Speaking of figures of merit, he pointed out that the power consumed was the important factor.

Prof. S. P. Thompson enquired what was the longest periods yet obtained with narrow-coil instruments. The decay of magnetism in large dynamos was so slow that very long periods were required; he himself had used a weighted coil for such measurements. He also wished to know why the figures of merit were expressed in terms of scale divisions on a scale at 2,000 divisions distance, instead of in angular measure or in tangents.

Mr. E. W. Smith asked what was the length of strip required to prevent permanent set when the deflections exceeded a revolution.

Mr. A. P. Trotter thought that in testing magnetic fluxes by the workshop ballistic instrument, the test coil might be left in circuit instead of putting in another coil. He wished to know what error was introduced by the change of damping caused by the resistance of the circuit not being quite constant.

In his reply, **Prof. Ayrton** said Mr. Boys had pointed out that the scientific way to lengthen period was not by weighting the coils or needles, but to weaken the control. Periods of five seconds

had been obtained. At present it was not easy to obtain longer periods, owing to difficulties in obtaining sufficiently thin strip and to the magnetism of materials.

BLACKPOOL.

At the meeting of the Blackpool Town Council on the 7th inst., the electric lighting question was an important item in the discussion. In the minutes of the Markets and Gas Committee it was decided that the report submitted by the assistant gas manager, Mr. Wm. Chew, upon the present electric lighting of the promenade and piers be received and printed, and a copy furnished to each member of the Council.

The Electric Lighting Committee reported as follows :

May 3rd.—Resolved, that the borough surveyor be desired to analyse the whole of the specifications and tenders for electric lighting received by the committee, and tabulate same for the committee's information and use. That the Council be recommended to discontinue the present system of electric lighting on the Promenade and piers, and to direct that the future electric lighting on the Promenade and piers be incorporated in the general scheme to be recommended by the committee for lighting the borough, or some parts thereof, by electricity under the Blackpool Electric Lighting Order, 1890.

In the discussion on these minutes

Councillor Bickerstaffe asked when the wonderful report of the committee was to be submitted to the Council. The delay was unfair both to to the public and the Council.

Alderman Cocker took exception to the minute recommending the discontinuance of the present system of electric lighting on the Promenade and piers. These large arc lights, he thought, were the best lights in England, and he did not see why they should be replaced by farthing rushlights. He proposed that the minute be referred back.

Alderman Parkinson said that he would second the amendment on the ground that by adopting the minute they were giving the Electric Lighting Committee a free hand to do away with these lights wherever they thought proper. It was unfair to ask the Council to do away with one of the greatest advertisements the town had ever had. Some months ago the present engines required repairing, and they were then told that in a short time a new system would be introduced. The new system had not yet been submitted, and had not the engines been repaired, there would not now have been any electric light.

Alderman Cardwell said that it was not intended to pull down these arc lights until the new system was ready.

Councillor Smith understood that the report of the committee was already in writing, almost ready to be presented.

Councillor Sergenson said that these arc lights were a stumbling-block to both the committee and the electrical engineers. They had had tests made of the arc lights and their cost, and although he should be glad to see the lights extended right along the Promenade, it was impossible, inasmuch as it would cost £7,000 per year, working on the present system. They proposed to recommend 2,000-c p. lights instead of the 6,000-c p. lights as at present used, and to fix them 30ft. high and 45ft. apart.

Councillor Whittaker did not endorse the statement of the previous speaker respecting the cost of an extension of the present lights. He was in favour of the amendment.

Councillor Pearson said that it would be absolutely impossible to present the report of the committee until one or two matters such as that before the Council had been cleared away by the Council. If the Council directed that the present arc lights should remain, then provision would have to be made in the tenders. He would point out, however, that not one engineer had spoken in favour of the lights. Even Mr. Siemens, the inventor of the lamps they were at present using, had now condemned them, and said that they could light the Promenade at a much less cost. It was intended that the lights instead of being suspended from a height of 60ft. should be hung at a height of between 25ft. and 30ft., and that instead of being 100 yards apart, they should only be 40 or 45 yards apart. Then again, instead of the lamps being of 6,000 c.p. each, they should be of only 2,000 c.p. The Promenade could be efficiently illuminated for the whole of the year for between £18 and £22 per lamp per annum, whilst the present lights cost £50 each for the season and double the amount for the whole of the year. The report would be issued immediately the Improvement Bill had been got out of hand. There were several legal difficulties that required attention, and it was only the inability of the town officials to devote the requisite time to the work that caused delay in the issue of the report.

Seven voted for the amendment and four against, the amendment being therefore carried.

Councillor Hampson proposed a further amendment providing that the future electric lighting of the Promenade should be incorporated in the general scheme to be recommended by the committee.

Councillor Whittaker seconded, **Councillor Sergenson** supporting.

The amendment was carried, and the minutes were then adopted as amended.

CHESTER.

REPORT BY DR. HOPKINSON ON THE ELECTRIC LIGHT SCHEME.

The minutes of the Watch Committee brought before the Chester Town Council at its last meeting, contained the following report by Dr. Hopkinson :

I visited Chester on Friday last, and have since carefully considered the circumstances of the electric lighting of Chester. Primarily there are two questions to be considered. First, the site for the generating station ; and, second, the system of supply to be adopted. The decision of these points depends on each other, for if the distance to which the electrical power is to be transmitted is considerable, an alternating high-tension system is essential ; whereas, on the other hand, if the distance is moderate, a direct low-tension system is preferable. With a low-tension system, by means of three wires, there is no difficulty in supplying economically a considerable quantity of electricity to three-quarters of a mile ; and this distance, for a smaller quantity, could be readily extended to a mile without serious loss. In Chester it is not probable that the demand for electricity will be great in the near future ; but, as in the case of all provisional orders, you are required to maintain the supply during the whole of the 24 hours, with the high-tension alternating system the machinery must be kept in motion during the whole time that the current is being supplied. This involves that the men must be in constant attendance upon the machinery, and steam must be kept up, at constant expenditure of fuel, the result being that your wages account will be doubled by the mere fact that the supply must be continuous. If, however, you make use of the low-tension system, accumulators can be applied, and these will supply current during the hours that the demand is small. It is true that accumulators are costly in the first instance, and that they are expensive to maintain, but in the case of Chester these drawbacks are much more than compensated by the saving of wages effected. It is a moot point among engineers whether it is worth while to use accumulators in large stations. The Kensington Company, carried out by Mr. Crompton, and the Westminster Company, carried out by Prof. Kennedy, make use of accumulators substantially for the reason which I have stated. But whether it is right in these large stations to use them or not, I am quite clear that they would be of enormous advantage in the small station required for Chester. I am, therefore, of decided opinion that, although if no site were favourable within your district, it would be easy to work at high tension with transformers, if there is a site favourable, a low-tension system, with a small battery of accumulators, is much to be preferred. When in Chester I inspected a considerable number of possible sites for the generating station. I deal with those first which appear to me to have least to recommend them.

The Dee Mills.—It has been proposed that water power should be employed, and that part of these mills should be purchased. I understand that the tide actually rises 4ft. above the weir at these mills. In dismissing this site I cannot put it more emphatically than by saying that if I had to use this site for generating a supply of electricity, I would use steam, and would not use the water power at all. The saving of coal which would be effected would be exceedingly small in comparison with the trouble involved by the irregular hours at which the water power can be used.

The Old Workhouse.—This has the advantage of being at present the property of the Corporation. The site is near the river, but for the present the coal would have to be carted. The drawback to this site is that it is somewhat remote from the centre of the area to be lighted—this means additional cost in conductors and additional waste in transmitting power. Therefore, although there would be no difficulty in working from this site, I would much prefer to have the site nearer to the centre of the town.

Tower Field.—This site is also, I understand, the property of the Corporation, and it is very near the site last referred to. The same considerations apply to it as to the last. The cost of supplying electricity from these two sites would be practically the same.

Sewage Works.—The attraction, at first sight, in this site is that some economy in wages may be effected by utilising the same staff of men, and the same boilers to work the electric light machinery and the sewage pumps. But I am informed that there is at this site no land available, and that what spare land there is will probably be very soon required for the purposes of the sewage works. If this site were adopted, the distance from the centre of supply is so considerable that the alternating high-tension system would be essential. There are two other sites which I did not actually visit, because it was clear that they had neither of them anything in their favour. They are Saltney, at a distance of 3½ miles from Chester, and Sandy Lane, at a distance of 1½ miles. We now come to the sites available within the town.

The Hop-pole Paddock.—This is an excellent site in the immediate neighbourhood of the cathedral. There is plenty of unoccupied ground, and I am informed that there would be no difficulty in obtaining any quantity of condensation water from the canal, provided it was returned to the canal. The use of condensers is of very considerable advantage in electric lighting stations ; it, of course, economises the quantity of coal used, and it avoids the production of steam, which may be, or may be alleged to be, a nuisance to neighbours. It has been suggested

that if this site were adopted for the station there may be opposition from the cathedral authorities, who may be apprehensive that the character of the neighbourhood of the cathedral would be changed disadvantageously. I have no doubt in my own mind that it would be very easy to put up a building on this site in such a way that there would be no reasonable ground for complaint. The site is most favourably placed in regard to the district to be lighted, and the advantage of water for condensation is considerable. Whether these advantages are sufficient to outweigh the opposition which may be raised if the site be adopted is a matter which those having local knowledge could judge far better than I.

Hamilton-place.—This site is near the Town Hall. There is abundance of space for the amount of machinery which would be required by the town for some time to come. The surrounding property is of a comparatively low class, and consequently there would be little fear of complaint from neighbours that they were disturbed by vibration. There is here no water available for purposes of condensation, but in all other respects the site is as good as the Hop-pole Paddock. If this were the only site available I should not have the least hesitation in recommending its adoption.

Since leaving Chester I have been informed that two other sites are available, the one in Lower Bridge-street, at the Albion Rooms, the other a chapel near the centre of the town. From a sketch plan which has been forwarded to me I gather that the Albion Rooms is a site about 50ft. wide and 150ft. deep. This is, of course, a very ample area for your purpose. The site is perhaps not quite so advantageous as Hamilton-place, but it would be thoroughly satisfactory.

The conclusion to which I arrive, then, is this—that your central station should be either in the Hop-pole Paddock, or in Hamilton-place, or at the Albion Rooms, that there is little to choose between these three, and that any one of them is adapted for your purpose. As already stated, as the distance is not too great, I should strongly advise the use of the low-tension direct-current three-wire system, with a small battery of accumulators. I understand that a sum of £15,000 has been sanctioned for the proposed works, exclusive of the land upon which they are to be erected. My estimate for the plant required for a thoroughly satisfactory generating works is £16,224. This, it will be observed, is exclusive of the cost of taking up the streets and making them good again, but includes the actual laying of the pipes in the trenches. The amount is somewhat in excess of the amount sanctioned, but it can be readily reduced with a corresponding reduction of the output if the figure of £15,000 is to be regarded as rigid. The length of mains provided for is nearly three miles—the length of streets within the compulsory area is about 1½ miles, hence this length of mains will provide for laying mains down one side of these streets and something considerable for extension beyond. This plant will enable you to supply at one and the same time 3,000 16-c.p. lamps, and would certainly enable you to permit 4,000 lamps to be connected to your circuits. The actual annual cost of working and maintaining the plant I estimate at £1,196. 10s. The revenue to be derived from the sale of electricity will, of course, depend on three things—upon the price you charge for the supply, upon the quantity taken by your consumers, and upon the hours during which they take it. In Manchester I have recommended the following method of charge, and it has been approved by the Board of Trade. For each unit of power in the maximum power demanded a charge not exceeding £3 per quarter, and in addition for each unit supplied a charge not exceeding twopence. The number of units per hour required by a consumer will be ascertained from time to time with a suitable instrument, all the lamps or other consuming devices being in use, and the units actually supplied will be ascertained by a meter. The former charge of £3 is to compensate the Corporation for the expense of providing machinery and conductors to be ready to supply current to the lamps if required, the latter charge is for the coal and wages consumed in supplying the current. For the information of those who do not know what a unit is, it may be said that a unit will supply about 80 8-candle lamps of suitable efficiency for an hour, hence for every such 8-candle lamp connected the consumer must pay a fixed charge of 2s. a quarter, and in addition thereto must pay $\frac{1}{40}$th of 1d. for every hour he uses it. This method of charge has the great advantage that it encourages that class of consumers who demand the supply for a considerable length of time. Such consumers cost the undertaker much less to supply. Taking the rates which it is proposed to adopt in Manchester, 4,000 16-c.p. lamps connected and 3,000 actually supplied at one time by the plant, and assuming that the lamps on the average were in use for 750 hours per annum, the revenue to be received would amount to £4,250. The average cost to consumers of their supply of electricity would be about 6d. per unit. Taking light for light, this would be equivalent to your gas at about 5s. per thousand. I understand that gas in Chester costs about two-thirds of this, and it would be a matter of very grave consideration for the Corporation whether they should endeavour to supply electricity at such a price that it would cost no more than gas. I understand that there are in Chester 740 gas lamps in the streets, and 55 Bray lights of 80 candles each, and that the charge for each of the 740 lamps is £2. 8s. per annum, this charge including the cost of lampposts and of lighting the lamps. There is no doubt that if the inhabitants of Chester did not themselves take an adequate quantity of current to give a paying return upon the works that something could be done with advantage in lighting the street lamps. The present lamps burn four cubic feet of gas per hour, and would be fairly replaced by an eight-candle electric lamp. The supply of electricity for this eight-candle lamp upon the rate of charge proposed would imply a fixed charge of 8s. per annum, and in addition thereto about £1 for the supply of electricity, altogether about £1. 8s. per annum. Bearing in mind that the gas company at present supply the lampposts and lighting, it would appear that the cost of electric light in the street would be about the same as the present cost of the equivalent gas.

On the whole, although I do not regard Chester as a specially favourable town for the electric light, I see no reason to doubt that an electric lighting central station in Chester would speedily pay its current expenses, interest upon the capital employed, and something over for extinguishing by depreciation the cost of the plant.

CANTERBURY.

A special meeting of the Canterbury Town Council was held on Wednesday last week at the Guildhall to receive the report of the Electric Light Committee as follows:

"The opinion of Mr. Moulton, Q.C., has been taken as to the materiality of the alterations made on behalf of the Brush Company in the suggested agreement and deed of transfer. Acting on the advice of the learned counsel, the committee recommended that some of these be agreed to, among others that the undertaking be named 'The Canterbury and Dover Electricity Supply Company,' but the accounts of the two towns are to be kept separate. There is some little hitch as to the terms of the agreement regarding payment of the costs incurred by the Council, and the committee reject an alteration limiting the power of the Council in applying for an order in the event of the default of the company."

The **Mayor** moved the adoption of the report, and said he would remind them that they were for the first time all agreed on this question. They unanimously decided to submit the drafts to Mr. Moulton, Q.C. The committee suggested that they should not have the agreement redrawn until their action that day had been submitted to the Brush Company.

Mr. Mills was of opinion that the matter had been before them quite long enough. He contended that the Council never ought to have applied for the order themselves. They should have let the Brush Company get it and take the responsibility. Now they had it, the question was what they were going to do with it. He had much pleasure in seconding the proposition that the agreement be sent to the Brush Company. There was one thing upon which they were all agreed—that the interests of the city should be protected. To satisfy them that such was the case he would ask the town clerk to read the last letter he had received from Mr. Moulton with regard to the promotion-money.

The **Town Clerk** then read the following: "With regard to Clause 1 of the agreement, I intended that my opinion should refer to what is spoken of in the papers before me as "promotion-money," as well as to the other matters mentioned in the clause. In my opinion, the terms between the Brush Company and the Canterbury Company should be matters that the Corporation should not touch in any way, or consider themselves responsible for, but their requirements should relate to the sufficiency of the plant to be put down. The powers that they have reserved approving of the first directors of the company and the articles of association, appear to me sufficient to ensure that no improper transactions take place in the formation of the company. I am of opinion that the whole of Clause 29 [enabling the Council to apply to the Board of Trade to revoke the order on insolvency or default of the company] should be retained."

Mr. Harris enquired why Canterbury should be tacked on to Dover. They would, he contended, get mixed up.

The **Mayor** replied that Mr. Moulton suggested that the accounts be kept separately. They must not expect the company to give up everything.

Mr. Wells pointed out that Clause 6 stated that the expenses of the transfer would fall on the Corporation and not on the company.

The **Town Clerk** explained that that was the application for the approval of the Board of Trade to the transfer.

Captain Lambert supported the proposition and contended that Mr. Moulton had safeguarded their interests.

Mr. Warren agreed that it was quite time the matter was brought to an issue. When Mr. Garcke acted for the company, they agreed to pay £350 down for obtaining the order. Now it had been altered, and Mr. Moulton thought that Clause 2, which stated that "the company instead of paying all the expenses of the Council in obtaining the order on the execution of the agreement, are to pay £35 then, and the balance when the transfer is executed," was reasonable. He (the speaker) could not agree with that. If he had a transaction with anyone and they made a promise, he should keep them to it. He contended that the company were shirking their promise, and he did not see why they should. He considered that whatever was decided by Mr. Garcke the company ought to pay.

The **Mayor**: Mr. Moulton does not agree with you.

Mr. Harris contended that they ought to keep the company up to the contract.

Mr. Mason said the matter seemed to be in a nutshell. They had spent £350 and would get nothing for it, whereas they might accept £35, and the remainder later on, and get the light into Canterbury.

Mr. Warren contended that they ought to have the £350 down.

The **Mayor** reminded members that shareholders having an interest in the gas company could not vote.

The motion was then put, six voting for, and one against.

ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL COMPANY, LIMITED.

The first annual general meeting of this Company was held on Thursday, June 9, at the City Terminus Hotel.

Mr. James Reek presided, and, in moving the adoption of the report, stated that it had been impossible to hold the meeting sooner, as they had been unable to get the accounts completed earlier, the vouchers having been in the hands of an official auditor in Germany in connection with the establishment of the German company. This business was, however, now completed. When forming the German company they paid to that company about £12,500, and a large proportion of this sum was still in their hands at the time the accounts were made up. They had only been at work at Schladern four or five weeks since they received permission to begin, and part of their working had been for their own purposes in making mandrels from the original ores. The position of the factory was a very good one, and there was railway communication within 800 yards. They had also land upon which they could extend the works as the business increased. He afterwards explained the various details and difficulties connected with the formation of the German company. They began business with 25 orders, but they would have plenty to keep them going. They were not proposing to increase the capital of the Company, for they were going to convert the £50,000 of 6 per cent. debenture stock into 7 per cent. preference shares, to be entitled to further dividends *pro rata* after the ordinary shares had received 10 per cent. per annum.

Mr. John Macfarlan seconded the motion, which was adopted.

The **Chairman**, in answer to questions, stated that the German property was valued at what it cost, and that the German Company had been established under the powers contained in this company's memorandum of association.

Resolutions were afterwards passed authorising the increase of the capital to £250,000 by the creation of 25,000 new shares of £2 each, the new shares and the 25,000 shares now unissued of the original capital to be called preference shares, the existing shares being in future termed ordinary shares.

NEW COMPANIES REGISTERED.

London Electric Wire Company, Limited.—Registered by Wilkins and Co., 112, Gresham House, E.C., with a capital of £50,000 in £5 shares. Objects: to acquire the business of electrical wire and other electrical apparatus manufacturers, hitherto carried on by T. and J. Willey, under the style of the London Electric Wire Company, at Playhouse-yard, Golden-lane, E.C., and generally to carry on and extend the said business in all its branches. The first subscribers are:

	Shares.
T. Willey, Fenchurch, Molyneux-park, Tunbridge Wells	1
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J. A. Hodgson, Anchor Works, Golden-lane, E.C.	1
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There shall not be less than three nor more than five Directors. The first are T. and J. Willey. Qualification, 200 shares. Remuneration, £3. 3s. each for each Board attendance.

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City and South London Railway.—The receipts for the week ending June 12 were £745, against £800 for the same period of last year, or a decrease of £115. The total receipts to date from January 1, 1892, show an increase of £1,136 as compared with last year.

PROVISIONAL PATENTS, 1892.

JUNE 7.

10773. **Improvements in conductors for the distribution of electrical energy.** Charles Edward Jackson, 33, Chancery-lane, London. Complete specification.

10774. **Improvements in and connected with junctions for electrical conductors.** Carrington Riddell, Gordon Smythe, 5, Doune Quadrant, Kelvinside, Glasgow.

10778. **An improved process and apparatus for making sodium, potassium, and like metals by electric action, and producing fused chlorides as a dry powder.** Henry Clay Bull, 13, Water-street, Liverpool.

10782. **Improvements in or relating to electric telegraphic signals-recording apparatus.** Richard Sweeney, 6, St. Nicholas-buildings, Newcastle-on-Tyne.

10792. **Improvements in incandescent electric lamps.** Frederick De Mayer and Gustave Simon Mahy[illegible], 323, High Holborn, London. Complete specification.

10777. **Improvements in electric batteries.** The Pr[illegible] pany, Limited, 60, Chancery-lane, London. (The [illegible] Company, Limited, Mersch.)

10818. **Improved electrical insulating conduit.** C[illegible] 57, Barton-arcade, Manchester. (Charles W. [illegible] United States.)

JUNE 8.

10823. **Improvements in the construction and [illegible] insulators for telegraph, telephone, and [illegible] purposes.** Ernest Wentworth Buller, 104, Col[illegible] Birmingham.

10847. **An appliance for actuating an electric [illegible] switch.** Richard Norman Lucas, Arthur James [illegible] and Anthony George, New Palace-chambers, [illegible] street, Westminster, London.

10850. **Improvements in primary voltaic batteries.** [illegible] Weymersch, 28, Southampton-buildings, Chan[illegible] London. (Complete specification.)

10855. **Improvements in secondary batteries.** Hugh [illegible] Kirkpatrick-Picard and Henry Thame, 112, St. [illegible] avenue, Shepherd's Bush, London.

10870. **Improvements in electrical measuring ins[illegible]** Henry Harris Lake, 45, Southampton-buildings, C[illegible] lane, London. (Edward Weston, United States.) [illegible] plete specification.)

10873. **Improvements in electrical indicator apparatus.** Ambrose McEvoy, 24, Southampton-buildings, [illegible] lane, London.

10876. **Improvements in the reflection and distribution [illegible] electric light.** Illius Augustus Timmis, 2, Great [illegible] street, Westminster.

JUNE 9.

10932. **Improvements in primary and secondary batt[illegible] electric lighting and power.** William Jones [illegible] Eastlake-road, Brixton, London.

10945. **An improved electrical advertising devic[illegible]** Walter Davies and Pennington Rowe Nunes, 15[illegible] London.

JUNE 10.

10948. **Improvements in microphones.** George Lee A[illegible] Walther Kottgen, 10, Jeffrey's-square, London.

JUNE 11.

10969. **Improvements in electric clocks.** Arthur Booth[illegible] 20, High Holborn, London.

11032. **An improvement in insulating supports for [illegible] conductors led in culverts.** John Thomas [illegible] Southampton-buildings, Chancery-lane, London.

11038. **Improvements in electric signalling apparatus.** Binswanger and Herbert John Coates, 11, Furni[illegible] Holborn, London.

11041. **Improvements in electrical safety devices.** Giovanni Linari, Bow Electric Works, Arnold-[illegible] London.

SPECIFICATIONS PUBLISHED.

1890.

13541. **Covering and insulating electric wires.** McCracken. Amended.

14033. **Electrolysis.** Abel. (Siemens and Halske.) [illegible]

1891.

8086. **Microphones.** Hoeser. Vogt.

8846. **Dynamo-electric, etc., machines.** Gra[illegible]

10894. **Electrometers.** [illegible]

12204. **Insulating electric wires.** Mackay.

12484. **Telephonic switching apparatus.** Bennett.

13837. **Electric meters.** [illegible]

1892.

6112. **Secondary batteries.** [illegible] Siemens and Mo[illegible]

7386. **Telephone receivers.** [illegible]

COMPANIES' STOCK AND SHARE L[IST].

Name.	Paid.
[illegible]	—
[illegible]	—
India Rubber, Gutta Percha & Telegraph Co.	[illegible]
House-to-House	—
Metropolitan Electric Supply	5
London Electric Supply	—
Swan United	5
St. James'	[illegible]
National Telephone	—
Electric Construction	[illegible]
Westminster Electric	—
Liverpool Electric Supply	5
[illegible]	3

NOTES.

St. Pancras is to have a new technical institute.

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Indiarubber.—It is stated that vast virgin forests of caoutchouc tree have been discovered in Upper noco.

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Deptford Tramways.—The London County Council have sanctioned the use of mechanical power other than steam on the Deptford and Greenwich tramways.

Alternators in Parallel.—The alternating dynamos mentioned last week, which were run in parallel at Madrid, were Lowrie-Parker machines, made at Wolverhampton.

Journal.—We have received the *Journal* of the Institution for June, containing papers on the electric arc, by L. P. Trotter, and on the E.M.F. of secondary batteries, by Dr. Gladstone and W. Hibbert.

Edison's Fee.—It is stated that the largest fee on record for an expert's opinion was given to Edison by the Niagara Company in the shape of a cheque for 10,000dols., or £8,000. It does sound large.

Spanish Telegraphs.—A complete strike of telegraph operators has taken place in Spain, 2,800 operators being idle. It seems probable, says Reuter, that the Government will be obliged to concede the terms demanded.

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Manchester.—Tenders for the electric wiring of that noble building, the Manchester Town Hall, are invited by the Gas Committee, specifications being obtainable on payment of two guineas. The tenders are to be sent in by July 5th.

Church Lighting.—St. Nicholas Cole Abbey, Queen Victoria-street, has been fitted for some time for electric light. Current is now turned on, and the 11 lamps of 300 c.p. give a steady and satisfactory light, which is greatly appreciated.

Bradford.—With reference to the tests of electric cars at Bradford, of which we have given recent accounts, we learn that so far as the electrical part of the installation is concerned, the trial has proved perfectly successful. Negotiations are now progressing as to the future working of the line.

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Taunton.—On Wednesday last week, at the meeting of the Taunton Town Council, the Electric Lighting Committee recommended that the Council should enter into a contract with the electric light company to purchase the whole of the buildings, plant, and works of the company for £9,300. The report was adopted.

Societe Internationales des Electriciens.—Members of this society, of which Mr. R. Aylmer, M.I.C.E., is hon. secretary and treasurer in this country, are requested to note that the society's office has been moved from 42, Parliament-street to 47, Victoria-street, S.W., and that the registered telegraph address is "Leclanché, London."

Stafford.—It was reported at the last meeting of the Stafford Town Council that the provisional order would expire in August, and it was resolved to ask the Board of Trade to extend the time. The committee had instructed their engineer, Mr. Bell, to make a canvass, and the matter is likely to be proceeded with if the canvass promises well.

Cardiff.—On Tuesday, at a meeting of the Lighting Committee of Cardiff Corporation, it was stated by the chairman that the sub-committee were not yet prepared to report as to a site for the electric light generating station. They were still waiting respecting the land, having had no satisfactory reply from either of the parties approached.

Bishopsgate-street Station.—The jury in the Bishopsgate fatal railway accident added, as a rider to their verdict of accidental death, that, although the accident had not been shown to have arisen from the defective lighting of the station, they wished to call attention to the fact that the station should be better lighted, more especially near the signal-box, and with the electric light if possible.

Lighthouses and Lightships.—The Royal Commission to enquire into the desirability and practicability of telegraphic communication between lighthouses and lightships and the shore will be constituted as follows: Lord Mount-Edgcumbe (president), Sir E. Birkbeck, M.P., Admiral Sir G. Nares, Admiral Sir L. M'Clintock, Mr. Mulholland, M.P., Mr. Munro Ferguson, M.P., Mr. J. Cameron Lamb, C.M.G., Mr. E. Graves, and Mr. J. A. Kempe.

Spalding.—At the last meeting of the Spalding Improvement Commissioners, upon the recommendation of the Gas Committee, it was decided to lay down an additional main, to secure the better lighting of the centre of the town, the cost of the proposed new work being under £300. Mr. Kingston advised the Board not to spend more than was necessary on their old gas works, as he held the opinion that gas lighting would in a few years be replaced by electric light.

Islington.—At the meeting of the Islington Vestry last Friday, the Special Electric Lighting Committee presented a recommendation that a provisional order authorising the Vestry to supply electricity in the parish should be applied for. The committee have arrived at this decision after exhaustive research and the advice of an eminent engineer, and they have come to the conclusion that it is possible to give the supply at 5d. per unit, as against 6d. in St. Pancras and 8d. as mentioned by other promoters.

Victoria-embankment.—We are pleased to see the London County Council are intending to take in hand the lighting of the embankment, once so resplendent with

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F. J. Lamb, Cotswold, Fairholt-road, Stoke Newington	1
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A. L. Don, 2, Hillside, Stonebridge, Willesden	1
J. A. Hodgson, Anchor Works, Golden-lane, E.C.	1
H. Capel, Anchor Works, Golden-lane E.C.	1

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PROVISIONAL PATENTS, 1892.

JUNE 7.

10715. **Improvements in conductors for the distribution of electrical energy.** Charles Edward Jackson, 55, Chancery-lane, London. (Complete specification.)

10716. **Improvements in and connected with junctions for electrical conductors.** Carrington Riddell Gordon Smythe, 5, Doune Quadrant, Kelvinside, Glasgow.

10735. **An improved process and apparatus for making sodium, potassium, and like metals by electric action, and producing ferric chloride as a dry powder.** Henry Clay Bull, 15, Water-street, Liverpool.

10742. **Improvements in or relating to electric telegraphic signals-receiving apparatus.** Richard Steenberg, 3, St. Nicholas-buildings, Newcastle-on-Tyne.

10762. **Improvements in incandescent electric lamps.** Ephraim Eby Weaver and Gustavus Benson Manypenny, 323, High Holborn, London. (Complete specification.)

10777. **Improvements in electric batteries.** The Princess Company, Limited, 60, Chancery-lane, London. (The Princess Company, Limited, Mersch.)

10818. **Improved electrical insulating conduit.** Carl Bollé, 57, Barton-arcade, Manchester. (Charles W. Jefferson, United States.)

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10823. **Improvements in the construction and attachments of insulators for telegraph, telephone, and such like purposes** Ernest Wentworth Buller, 104, Colmore-row, Birmingham.

10847. **An appliance for actuating an electric transformer switch.** Richard Norman Lucas, Arthur James Mayne, and Anthony George, New Palace-chambers, Bridge-street, Westminster, London.

10850. **Improvements in primary voltaic batteries.** Henry Weymersch, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

10855. **Improvements in secondary batteries.** Hugh Fitzalis Kirkpatrick-Picard and Henry Thame, 112, St. Stephen's-avenue, Shepherd's Bush, London.

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10999. **Improvements in electric clocks.** Arthur Boothe Webber, 20, High Holborn, London.

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11038. **Improvements in electric signalling apparatus.** Gustav Binswanger and Herbert John Coates, 11, Furnival-street, Holborn, London.

11041. **Improvements in "electrical safety devices."** Vittorio Giovanni Lironi, Bow Electric Works, Arnold-road, Bow, London.

SPECIFICATIONS PUBLISHED.

1886.

13341*. **Covering and insulating electric wires.** Newton. (McCracken.) (Amended.)

14033. **Electrolysis.** Abel. (Siemens and Halske.) (Second edition.)

1891.

8696. **Microphones.** Huelser. (Vogt.)

8806 **Dynamo-electric, etc., machines.** Gravier.

10894. **Electrometers.** Boys.

12384. **Insulating electric wires.** Mackay.

12484 **Telephonic switching apparatus.** Bennett.

16931. **Electric meters** Grassot.

1892.

6112. **Secondary batteries.** Lake. (Sleicher and Mosher,)

7398. **Telephone receivers.** Hess.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
India Rubber, Gutta Percha & Telegraph Co.	10	20½
House-to-House	5	5⅜
Metropolitan Electric Supply	—	7⅜
London Electric Supply	5	⅞
Swan United	3½	4⅓
St. James'	—	8
National Telephone	5	4⅜
Electric Construction	10	6¼
Westminster Electric	—	6 1/16
Liverpool Electric Supply	5	5¼
	3	3½

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Cardiff.—On Tuesday, at a meeting of the Lighting Committee of Cardiff Corporation, it was stated by the chairman that the sub-committee were not yet prepared to report as to a site for the electric light generating station. They were still waiting respecting the land, having had no satisfactory reply from either of the parties approached.

Bishopsgate-street Station.—The jury in the Bishopsgate fatal railway accident added, as a rider to their verdict of accidental death, that, although the accident had not been shown to have arisen from the defective lighting of the station, they wished to call attention to the fact that the station should be better lighted, more especially near the signal-box, and with the electric light if possible.

Lighthouses and Lightships.—The Royal Commission to enquire into the desirability and practicability of telegraphic communication between lighthouses and lightships and the shore will be constituted as follows: Lord Mount-Edgcumbe (president), Sir E. Birkbeck, M.P., Admiral Sir G. Nares, Admiral Sir L. M'Clintock, Mr. Mulholland, M.P., Mr. Munro Ferguson, M.P., Mr. J. Cameron Lamb, C.M.G., Mr. E. Graves, and Mr. J. A. Kempe.

Spalding.—At the last meeting of the Spalding Improvement Commissioners, upon the recommendation of the Gas Committee, it was decided to lay down an additional main, to secure the better lighting of the centre of the town, the cost of the proposed new work being under £300. Mr. Kingston advised the Board not to spend more than was necessary on their old gas works, as he held the opinion that gas lighting would in a few years be replaced by electric light.

Islington.—At the meeting of the Islington Vestry last Friday, the Special Electric Lighting Committee presented a recommendation that a provisional order authorising the Vestry to supply electricity in the parish should be applied for. The committee have arrived at this decision after exhaustive research and the advice of an eminent engineer, and they have come to the conclusion that it is possible to give the supply at 5d. per unit, as against 6d. in St. Pancras and 8d. as mentioned by other promoters.

Victoria-embankment.—We are pleased to see the London County Council are intending to take in hand the lighting of the embankment, once so resplendent with

Jablochkoff lamps. After consideration the Highway Committee consider it would be advisable for the Council to have their own installation for this purpose, the cost of installation being not over £10,000, and the cost of maintenance not to exceed £2,000 a year. Subject to an estimate, they propose to put this installation in hand very shortly.

Central London Railway.—The Select Committee of the House of Commons, to whom was referred all the London electric railway schemes, having declined to consider in the present Parliament the scheme promoted by the Central London Railway Company to extend their authorised railway from the Mansion House to Liverpool-street Station, the promoters have come to an arrangement with the whole of the opponents, numbering upwards of 10, whereby no further opposition will be offered to this extension in either House.

Lighting of Private Residences.—Mr. T. Burt Heywood, of Woodhatch, Reigate, has decided to adopt the electric light in his private residence, and has placed the contract for the work with Messrs. Drake and Gorham. The power will be derived from a 7-h.p. Otto gas engine driving an eight-kilowatt dynamo. This firm has a large number of other country house installations in hand, including Callaly Castle, Northumberland, for Major Browne; Chalfont Park, Slough, for Captain Penton, M.P.; and Lawnhurst, Didsbury, for Mr. Henry Simon.

Paris.—Those electric light companies that have adopted the system of open conduits with forced air ventilation, such as is used at St. Pancras, have shown considerable foresight. We notice that at Paris another explosion took place, this time in the Rue Bréda, Thursday last week, supposed to be from escaping gas exploded from a spark. That the gas was to blame is evident from the fact that no sooner was the cover replaced than it was again forced up and broke in two. Certainly here electrolytic action, the cause sometimes attributed, could not have been at work, and an escape of ordinary lighting gas must have been present.

Scarborough.—At the last meeting of the Scarborough Town Council, the report of the Lighting Committee was brought forward. The committee resolved that before any further steps be taken it is desirable that the committee should have an interview with Mr. Bernard Drake, the electrical engineer to the Council. They also resolved that the town clerk should write to six towns where electric lighting is in operation, and ascertain from them what was the cost of their plant, etc., what number of electric lights they have in use, the amount of the annual expenditure, and the amount of the annual receipts. The further consideration of these minutes was deferred to the next meeting of the committee.

Hammersmith.—At the Hammersmith Vestry meeting last week, with reference to the application of the Putney and Hammersmith Electric Lighting Company (consent to which was given in January last) the committee reported they had again considered the letter from the company, stating that the conditions upon which the Vestry were prepared to give their consent to the West London electric lighting provisional order were so onerous that they had no option but to abandon the application, and asking that the £300 deposited with the Vestry be returned. They recommended that the money be returned, and this the Vestry agreed to, having refused the application on a previous occasion, when the report was referred back for further consideration.

Varley Memorial.—A meeting attended by Messrs. R. E. Crompton, T. E. Gatehouse, W. A. Gorman, Prof. D. E. Hughes, T. Parker, Major Flood Page, A. Stroh and J. W. Swan, was recently held at the rooms of the Institution of Electrical Engineers for the purpose of discussing the best method of recognising the great services of Mr. Samuel Varley to the electrical industry. The meeting was unanimously of opinion that the services of Mr. Samuel Varley to the electric industry deserved substantial recognition, and that everyone interested in electric engineering should be invited to join the committee for the purpose of discussing the best form that this recognition should take, and that a draft circular should be prepared ready for submission to a meeting of the committee, which should be invited to attend at the rooms of the Institution of Electrical Engineers at 28, Victoria-street, on Friday, July 1, at four o'clock.

Worcester.—We are glad to find the Councilmen of Worcester have determined to proceed with the work of electric lighting instead of wasting more time in discussing systems after the decision. A meeting of the Watch Committee was held last Friday, the mayor (Mr. W. Holland) presiding. The resolution of the Council referring to the committee the duty of recommending as to what portions of the Brush Company's tender for the electric lighting scheme should be accepted was reported. Alderman Higgs proposed that the company should be requested to tender for a supply of 5,000 lamps only. He urged that the present tender providing for an installation of 20,000 lamps, with 12,000 constantly running, was greatly in excess of the present or prospective requirements of the city. The motion was not seconded. The resolution of the committee was referred to a sub-committee to consider and report what part of the work should be proceeded with.

State Telephones.—In the House of Lords on Tuesday, Lord Balfour of Burleigh moved the second reading of the Telegraphs Bill, which, he said, was introduced for the purpose of giving effect to a Treasury Minute of May 24 last. The main feature of the Bill was the revision of the present system of telephones. There was only one clause to which it was necessary to call attention. In some districts of the country the inhabitants were deprived of the advantages of telephonic communication by the unwillingness of landlords to allow wires to be affixed to their property. The clause to which he referred proposed that where assent was unreasonably withheld the Postmaster-General might apply to the Railway Commission to authorise the fixing of wires, and that, if the Commission made an order and the owner was dissatisfied, the order should be laid before Parliament and dealt with in the same way as provisional orders. He thought their lordships would agree that the time had come when the obstruction of one or two persons should not be allowed to deprive the inhabitants of a large district of the advantages of telephonic communication.

Engineers for Spain.—Mr. E. G. Pink, plaintiff in the action of Pink *v.* Electricity Supply Company for Spain, Limited, was engaged under contract as resident engineer in Madrid. Being unable to agree with the manager in Spain on technical matters of importance, plaintiff, after a fruitless appeal to the directors of the company in London, offered to resign, and was dismissed by the said manager. He returned to London under protest, and eventually commenced proceedings. The case was finally settled out of court by the defendants paying three months' salary in lieu of notice, first-class travelling expenses, and all costs. Mr. Pink has also received a letter from the company stating that the directors feel assured he did his best to promote the interests of the company, and that they much regret that the termination of agreement was unavoidable

owing entirely to a difference of opinion with the general manager of the company in Spain, due in a great measure to the want of a common language in which they could converse freely. The directors do not impute any blame in the matter, and recognise at the same time the important economies effected by him in the working of the station. They further state they will be happy to recommend him for the post of chief engineer to any similar undertaking. The moral seems to be—learn the language of the country in which you are going to be engineer.

Lighting the Guildhall.—At the meeting of the Commissioners of Sewers last week, Mr. Pannell presented the report of the City Lands Committee, recommending that the Guildhall and offices, library, and Council chamber should be fitted with electric light installations, at an estimated cost of about £1,750 for the installations and £500 per annum for the current and maintenance. Mr. Pannell explained that the total cost would be £4,500, and the annual expense on completion would be £1,500, against £1,156 for the present supply of gas. Mr. MacGeagh asked whether the City of London Court could be supplied with the electric light, the cost of which would be paid out of the funds of the Court. Mr. Stanley asked whether the committee had made any arrangement with the City of London Electric Lighting Company with respect to the cost per unit. Mr. Pannell replied that it would be obvious that the committee could not enter into negotiations as to prices until an instruction had been received from the Court. Mr. Stanley explained that the company could easily supply the current at 6d. per unit, and make a large profit, but he believed that they had the power to charge 8d. per unit. Mr. King said it might be possible at a future date to have the installation at Guildhall for the supply of the building and the Mansion House too, but at the present time it was thought that they should give the electric lighting company the chance of supplying the current. Mr. Wallace expressed an opinion that the work ought to be put out to contract. Mr. A. T. Layton, who said he had had some experience of electric lighting, thought the Guildhall could not be supplied for £500 per annum. Mr. Pannell believed the work could be done for the estimated amount, the committee having been assisted by the advice of Mr. Preece, and he thought also that it would be better for the Corporation to wait before taking upon itself the responsibility of doing the work. The report of the committee was then adopted.

Yarmouth. — The Yarmouth Town Council have decided that they will employ a consulting engineer and get out plans and estimates, but that they will not actually pass a resolution to put down an installation at the present moment. At the meeting last week, it was stated that the town clerk had informed the committee that the Council could lay down suitable and sufficient distributing mains for a general supply of electricity to the town. It was agreed by the committee—(*a*) that the Town Council be recommended to carry out the necessary works for providing a system of electric lighting in the borough, and that the providing of electricity be not handed over to a company; (*b*) that Messrs. Crompton, Messrs. J. E. H. Gordon and Co., Messrs. Woodhouse and Rawson, Messrs. Hammond, the Planet Electrical Engineering Company, and the Brush Company be asked to submit schemes with estimates at which they would be prepared to carry out an installation suitable for the requirements of the town, and that the borough surveyor be instructed to furnish plans and the necessary particulars; (*c*) and that the committee be authorised to employ a consulting engineer to advise them on the specifications and tenders. When this report came before the Council, Mr. de Caux asked for the cost. He did not think the Corporation should enter into any such speculation as was proposed. The report as to the experience of other towns did not give a rosy view, and certainly did not lead to the conclusion that the scheme could be carried out without charge to the ratepayers. He was perfectly satisfied that if they entered into the matter it would land the town in enormous expense. He moved the expunging of the report. Mr. Martins urged the adoption of the scheme in order to prevent the introduction of a monopolising company. Mr. W. Palmer said the question was whether the Corporation were to retain the control in their hands, or to hand it over to a private company. Mr. Tomkins, while approving the introduction of the new light, preferred to know what the cost would be before taking any definite steps. Mr. de Caux's resolution was then put and lost by 17 to 13. A further amendment, moved by Mr. Tomkins, and seconded by Mr. J. H. Palmer, that paragraph (*a*) be struck out of the report, was carried by 18 to 4. The report thus amended was then adopted.

Expert's Opinion.—An amusing case came before the St. Martin's County Court last Friday, when the value of an electrical expert's opinion was called in question. The case was a cross summons by Mr. Ernest Claremont, described as manager to the Metropolitan Electric Supply Company, for £10. 10s. fee for testing a lamp, against a county court summons by Messrs. Smith and Son, of the Strand, for jewellery received and not paid for. It seems from the evidence given by Messrs. Smith and Mr. Claremont, that when the latter was summoned, a counter-claim for testing was sent in, Messrs. Smith denying that any order was given for an expert test as claimed. Their window had been fitted with electric light by F. Suter and Co., and it was noticed that a slight dampness was observable. Mr. Claremont called attention, or had his attention called to this fact, and the suggestion was made he should take the lamp home and test it, Messrs. Smith maintaining this was a simple friendly transaction. Not so Mr. Claremont, who swore on oath it was his opinion he had been called in as an expert, that he never usually accepted a fee of less than 25 guineas, that testing by a photometer was a very delicate test, one of the most delicate an electrician could undertake, that the test took him 300 hours with considerable expense for current. Amongst other questions, Mr. Claremont answered that he tested for extraordinary heat in the lamp and for life of the lamp, that a good lamp should give out no heat at all, absolutely none; that the cause of extra heat would be bad vacuum or bad manufacture, that it was a most delicate test, that one hour would be enough to test for vacuum, but 300 hours was not too much to test as desired, that 10 guineas was certainly not too much for testing a three and ninepenny lamp, and that they should not have called in expert opinion; that he did not send in the account until the summons was issued, because it took two months, and he had not furnished the report. His report was that he had tested the 8-c.p. 100-volt lamp, and could find absolutely nothing the matter with it; it gets a little hot when overrun, but not sufficiently so to cause the dampness complained of. The manager of Messrs. Smith gave evidence to the effect that no one considered that a charge was to be made; and Mr. Suter contradicted Mr. Claremont's statements as to the entire absence of heat, the necessity for a long test, and the fairness of the charge. The Court found that there was no warrant for such a large charge, and awarded one guinea on account of the claimed test.

METERS FOR RECORDING THE CONSUMPTION OF ELECTRICAL ENERGY.*

BY CHARLES HENRY WORDINGHAM, A.K.C., STUD.INST.C.E.

(Concluded from page 592.)

A most ingenious modification has been introduced into this meter by Mr. Miller, of the Kensington and Knightsbridge Electric Light Company. He employs only one clock, which drives a soft iron disc through the differential gear already described. The disc revolves in front of a coil carrying the current to be measured and is retarded by it. This admirable device does away with the whole trouble of synchronising, as there is only one clock, and prevents the danger of the record being destroyed by one clock stopping. There should be an excellent future for this meter.

An adaptation of the Aron meter, made by the same inventor, supplies a great want felt by users of secondary batteries—viz., an indicator of the amount of charge in the battery. Now it is obvious that if the main current be reversed in the wattmeter form, repulsion will ensue and the pendulum will be retarded, the meter, in consequence, registering backwards Mr. Miller found that, with the ordinary form of coils, if the current was reversed, the indications were not accurate, owing partly to the slow speed. He accordingly altered the form of the coils and shortened the pendulums, and in this way he succeeded in producing a meter that would register accurately, which ever way the current flowed. In order to ascertain the condition as to charge of a secondary battery, he charges it fully through this meter, and notes the quantity registered. The battery is then allowed to discharge through the meter, and the instrument goes back. When the time for recharging arrives, all the attendant has to do is to keep on the charging current until the meter shows its original reading. In this way the exact state of the battery is shown by an inspection of the meter.

The Richard Frères meter has been adapted to the same purpose by so mounting the fine wire coil that it can deflect on either side of its position of rest, thus driving the counting train either way according to the direction of the current. It has also been arranged that if a fixed loss in the battery be assumed, it can be allowed for by inserting a resistance in series with the fine wire coil when charging, thus making the meter register only the percentage of the charging current that will be returned.

Oulton-Edmundson Meter.—In this the ordinary pendulums are replaced by horizontal balances oscillating at about one-quarter the speed, the torsion being supplied by a straight flat spring, which also serves as a suspension. The two clocks are driven by one mainspring. The controlled pendulum carries two fine wire coils, one swinging within the main coil, and the other above it. Each of the movable coils consists of two circuits, one placed across the lamp leads in the ordinary way, the other forming a shunt across the main coil; the small current passing through this second circuit is stated to be required in order to raise the constant at the higher readings. This meter in its present form has only recently been introduced.

Kelvin Meter.—One of the latest additions to this class of meter comes from the hands of Lord Kelvin, the inventor who has produced so many electrical measuring instruments of unsurpassed accuracy. As a laboratory instrument, no doubt the meter about to be described is extremely accurate, but it may be doubted whether it is suitable for practical use. In the first place, it is somewhat unreasonable to expect a consumer to descend every day to his coal-cellar, it may be, in order to wind up an instrument of which he is, in all probability, afraid and looks upon as some infernal machine. Next, it has working parts of extreme delicacy, and is unsuitable to put into the hands of an ordinary linesman. Lastly, it is preferable to have a continuous, rather than an intermittent integrator.

The instrument is a combination of a weight-driven clock which automatically breaks the circuit when it requires winding, an ampere balance, and an integrating cam. A fixed coil carries the main current, and in front of it is placed a fine wire coil carried at the end of a vertical aluminium lever free to turn on knife-edges about a horizontal axis. The lower end of this lever has attached to it a train of counting wheels, the first one of which can roll on a cylindrical cam which is kept revolving at a constant speed by means of the clock. When a current passes through the main coil the other is repelled, and the rolling wheel, which originally stood clear of the cam, moves over it, is raised by it, and rolls on its surface, thus actuating the counting wheels. Now the cylindrical surface of the cam is cut away screw fashion, so that, when at one end of it, the wheel only rolls for a small portion of its revolution, and at the other remains on it for the greater part of a revolution, the time it remains on being proportional to the current corresponding to the position of the lever. A series of grooves are cut on the surface of the cam so that, once engaged, the wheel cannot shift sideways. A scale is provided over which the lever moves, enabling the instrument to be employed as an ampere gauge and its indications to be checked. The constant of the instrument can be altered so as to adapt it to various currents, by altering the weight on a horizontal rod projecting from the movable arm, and by altering the height of a nut on a vertical screw.

CLASS 4.

Edison Meter.—This is a meter adapted to continuous currents only, and depends for its operation on the electrolytic action of the current. A definite portion of the current to be measured is shunted through a bath containing a solution of zinc sulphate, the electrodes being of amalgamated zinc. The meter in its latest form contains three essential parts: (1) the electrolytic cell and compensating coil, (2) the shunt resistance, and (3) a device for keeping the electrolyte from freezing. The case of the meter is of well-seasoned hard wood, specially prepared to exclude air and to secure good insulation, and its front is closed by a substantial sheet-iron door.

(1) The cell. This is of bottle form, and is covered to avoid evaporation. It is partially filled with a 10 per cent. zinc sulphate solution in which are suspended zinc plates supported by screws and nuts on ebonite distance-pieces, connection being made to them by copper rods held by spring clips. The plates are prepared by being first thoroughly cleaned, then covered on the top and for a short distance up the rod with asphalte varnish, and lastly, amalgamated and dried. The positive plate is weighed before being immersed. The size of the plates is regulated by the maximum current the meter is intended to carry, the quantity of zinc allowed for being at the rate of 150 milligrams per month for every ampere of nominal capacity. If the meter is likely to run at its full load for a large number of hours during the day, a larger cell is required than the above amount would give. In calculating the quantity that has passed through the meter, one ampere flowing for one hour is taken as depositing 1,224 milligrams of zinc. The counter E.M.F. of the cell decreases as the temperature rises, and its resistance also falls; in order to compensate for the error thus introduced, a copper coil, the resistance of which of course increases with the temperature, is placed in series with the cell, and is so adjusted that the effective resistance of the combination is identical at 50deg. F. and at 86deg. F., varying about 1 per cent. between these two points. As regards the change of effective resistance with change of current, it is found that the increase in counter E.M.F. is about compensated for by the fall in resistance of the cell.

(2) The shunt resistance is of German silver, and has such a value that $\frac{1}{975}$th part of the whole current flows through the cell. The resistance of this material varies 1 per cent. for every 45deg. F. change in temperature, and the maximum temperature attained by the meter is about 120deg. F.; hence the error from this source does not exceed 2 per cent.

(3) The cell is kept from freezing by means of an incandescent lamp placed in the case of the meter and automatically lighted by means of a thermostat when the temperature falls below a certain value. This portion of the apparatus consists of a compound metallic strip which alters its curvature when the temperature falls, completing the circuit through the lamp. The contact point is carried

* From the *Transactions* of the Institution of Civil Engineers.

by a screw having a pitch of $\frac{1}{16}$in., with a hexagon head, the faces of which are numbered. In this way the temperature of contact can be adjusted to within 2deg. F.

A curve given by Mr. W. J. Jenks in a paper on this meter, read before the American Institute of Electrical Engineers, shows that after three amperes the rate of deposit is absolutely constant up to 20 amperes; the meter having, therefore, a sevenfold range, and registering with the smallest current, the error is in favour of the consumer.

The chief objections to this meter are the remarkably small fraction of the current that is measured—any error, either in deposit or in weighing the plates, being multiplied nearly a thousandfold; the necessity for the consumer relying entirely upon the good faith of the supply company for the accuracy of his account—it being absolutely impossible for him to check his consumption from day to day, or to ascertain for himself the amount registered by his meter; and the constant attention required—the plates having to be removed every month, weighed and replaced.

This meter is extensive use in Ameria, and was used with satisfactory results at Eastbourne before the system was changed to an alternating-current one; it has not, however, met with much favour in this country.

Lowrie-Hall-Kolle Meter.—This meter attempts to apply the electrolytic method to the measurement of alternating currents, and was worked out by the three inventors whose names it bears when they altered the system at Eastbourne from continuous to alternating, the Edison meter having given, as already stated, satisfaction in the former case. In series with the converter is placed a secondary cell, giving a pressure of two volts, and an electrolytic bath. The effect of this is to raise the positive wave bodily by two volts, and to diminish the negative wave by the same amount, the effect being the equivalent of two volts always acting in one direction through the circuit—the current flowing being proportional to the number of lamps turned on. The whole current thus passed through the secondary cell, but so far from it having any ill effect it seemed to prevent sulphating. It was found that in a suitable electrolytic solution, any metal can be by this method deposited by an alternating current, and the quantity so thrown down used as an indication of its amount.

Improvements in other types of meter prevented this being brought to a state of perfection in spite of its being fairly promising. It was, however, open to at least one serious drawback—namely, if the alternating current was switched off, and any lamps left turned on, the cell discharged through them and caused a registration to be effected in the electrolytic bath; moreover, the secondary cell had to be recharged every three months, and there can be little doubt that the inventors would have had trouble with the direct electrolytic action of the alternating current, for it has been shown that without any secondary battery being in circuit, such a current will cause deposition of an uncertain amount, depending on the size of the electrodes.

TESTING OF METERS.

In the commercial employment of meters, an important matter is their efficient and rapid testing; and it may be of some interest if the author describe the arrangements designed and used by him for testing the meters employed by the London Electric Supply Corporation. Their system being an alternating one, only meters adapted to this class of current are provided for. The kinds used are Ferranti mercury, Ferranti-Wright and Frager.

The method adopted in testing the mercury meters is to string a number together with their main coils in series with one another, and with an adjustable non-inductive resistance, the shunt coils being connected in parallel across the converter terminals.

It may be well here to call attention to a source of error that is likely to be overlooked in testing any kind of shunted meter. When in use, the shunt coil has one end attached to the shunt terminal and the other to the converter end of the series coil. If the meters be connected in series, each being allowed to feed its shunt in the ordinary way, two errors will be introduced, as an inspection of Fig. 11 will show: (1) With large currents in the series coils, the shunt of the meter nearest the converter is the only one receiving its full pressure (100 volts); the second has a pressure that is less than the 100 volts by an amount equal to the drop of pressure in the first; the third is deficient by the drop in two meters, and so on, the last of a long series receiving much less than 100 volts. (2) The last meter is the only one that has flowing through its series coil the current that is measured; the last but one receiving in addition to this the shunt current of the last; the third from the end those of the last two; and so on to the one nearest the converter, which receives in addition to the measured current the sum of all the shunt currents of the other meters. These two errors are easily and completely disposed of by running a separate lead from the converter to excite them, as shown in Fig. 12.

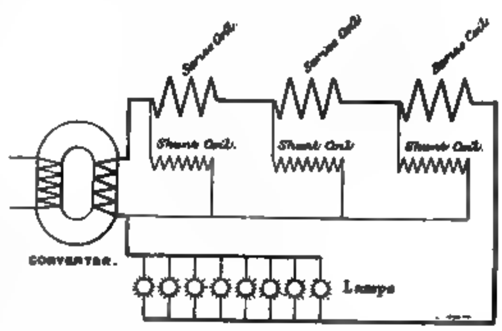

FIG. 11.

To resume, the reading of the dials having been noted, the desired current is thrown on, and kept on for a time sufficient to obtain a reading of such a magnitude that an error of ± 0·1 would not affect the constant more than 1 per cent. It is then thrown off, and the reading is taken when the meters have come to rest. The number of revolutions per hour shown by the dials having been calculated from the difference of the readings, it is divided by the product of the current and the pressure; this gives the number of revolutions per watt-hour, and, when multiplied by 1,000, the "constant"—*i.e.*, the number of revolutions—per Board of Trade unit. The pressure, and therefore the current, is maintained constant within one half per cent., by the means described below.

Obviously there is a slight error in this method owing to the meters requiring time to get up speed, but this is compensated for in practice by their taking approximately the same time to slow down after the current is removed.

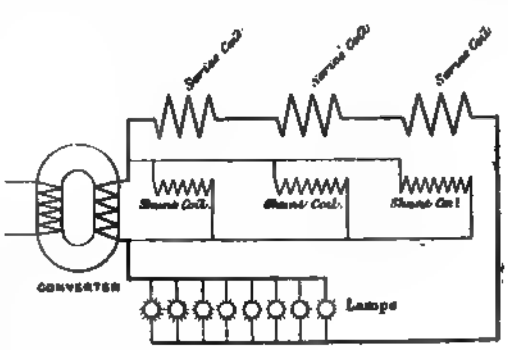

FIG. 12.

When the current is so small that the time required for a run is inconveniently long, the meters are allowed to attain their full speed with that current and the centre hands are counted, the number of revolutions at the end of 1, 2, 3 . . . minutes being noted. With practice, it is easy to estimate to the tenth of a revolution, and these meters revolve with such remarkable regularity that repeated experiments have shown it to be quite safe to infer the constant from a two-minutes count. The rate per hour of the dials having been calculated, the constant is found as before. This meter, as has been shown, has so smooth a curve that it is sufficient to adjust it at two points, one being that of maximum current and the other one-tenth maximum.

The Ferranti-Wright meters are tested in exactly the same way as the last, except that the first method is always used, the centre needle never being counted. Three points are usually determined in the curve, one being the maximum

current, one about one-seventh maximum, and one midway between the two.

The Frager meters also are strung in series, and the same precautions observed as regards exciting their shunts, but their different nature requires a different method of testing. There are two stages: (1) In the first the clock motor is timed and adjusted until it beats seconds within 2 or 3 per cent. (2) The meter as a whole is tested. The dials being set to zero, and the snails being in such a position that the levers have just left them (this is to allow them to become

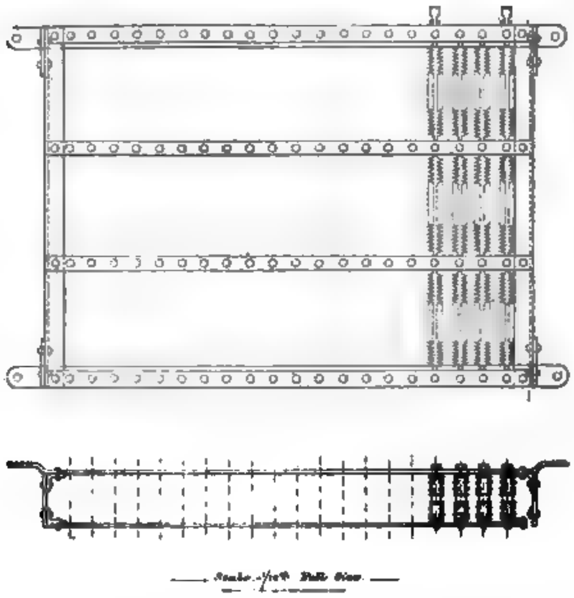

FIG. 13.

steady before engaging with the snails), the desired current is thrown on and the pressure, and therefore the current, kept constant within ½ per cent. until the snails have made six complete revolutions. When the lever of the slowest meter has left the snail, the current is taken off and the readings are noted. The known percentage errors of the clocks having been allowed for, the number of Board of Trade units that would have been registered by each in an hour is calculated, and this is compared with the actual amount that would have passed in an hour. The percentage error is then corrected by altering the ratio of the wheels between the snail spindle and the train as already described.

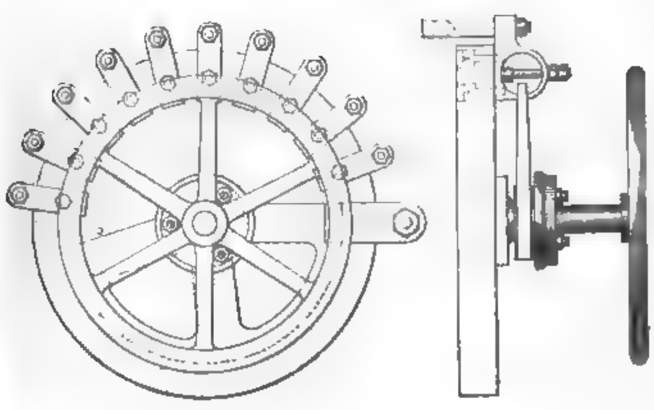

FIG. 14.

Passing on to the arrangements for performing the above tests, it may be well to remark that the space at the author's disposal was extremely limited: two rooms, one above the other, each 28ft. long, 12ft. wide at one end tapering away to 3ft. at the other, having to suffice for testing-room, stores, Frager meter repairing shop, and for containing the converters. The upper room was taken for testing, the lower for workshop, converter-room, and stores; a hand-lift in one corner formed a convenient means of communication. The testing-room is all that need be described; the narrow end is partitioned off, and a reflecting galvanometer and Wheatstone bridge placed in the chamber so formed; the galvanometer rests on a shelf supported on H-iron cantilevers let into the wall, thus avoiding vibration. A space about 6ft. wide on the wall opposite the windows is faced with solid teak thoroughly coated with shellac, and to this are attached all switches; 5ft. 2in. from the floor a shelf, supported like the one for the reflecting galvanometer, serves as a steady base for the ampere balances. Above this are fixed the primary fuses and switches, from which vulcanised indiarubber-covered cables, carried in iron pipes chased into the wall, lead to the converters in the room below.

A standard horizontal, tube-pattern Cardew voltmeter, made by Messrs. Goolden and Co., is fixed below the switches, and shows the pressure on the shunt coils.

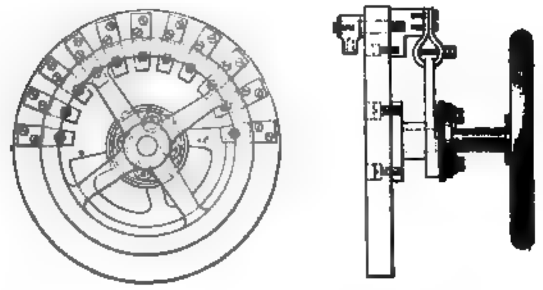

FIG. 15.

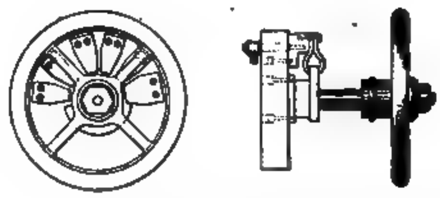

FIG. 16.

Beneath the shelf are placed all the secondary switches. With a few trifling exceptions, the secondary connections for large currents are made of bare copper strip 1in. by $\frac{1}{16}$in. supported on teak cleats, coated with shellac, the number of strips being proportioned to the current to be conveyed. This is a very convenient and cheap method, and, when neatly done, looks well.

The mercury and Ferranti-Wright meters stand on narrow teak shelves one above the other, fixed on light T-iron cantilevers projecting from the wall.

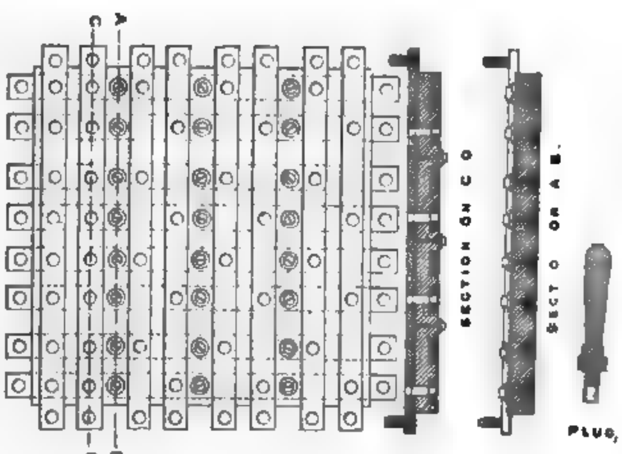

FIG. 17.

It seemed desirable to be able to carry on tests of all three kinds of meter simultaneously, and so three separate testing circuits, each with its adjustable resistances and switches, were provided. A fourth circuit was added, for running meters from 18 to 24 hours continuously on full load, to determine whether they would rise to an unsafe temperature.

An obvious way of reducing the cost of testing is to feed the main coils with current at a low pressure, say 10 volts, and to excite the shunts with only 100 volts. After careful consideration the author decided not to adopt this plan, partly because he was not absolutely satisfied that it gave results identical with those obtained when both were

excited from the same source, and partly because with many meters in series the pressure would have to be raised with large currents, and the additional complication entailed seemed hardly compensated for by the saving in expense. This objection clearly does not apply to the heating test, in which the shunts are not excited and no measurements are made; and, accordingly, a converter giving current at 10, 20, or 30 volts pressure at will in its secondary is employed, the lowest pressure that will give the desired current through the circuit being used, this pressure varying with the number of meters in series.

The mercury meter testing circuit is provided with resistances having a conductivity of 1·11 mho, divided into three sets—one of one mho, having 10 steps of 0·1 mho each; one of 0·1 mho, divided into 10 steps of 0·01 mho each; and one of 0·01 mho, divided into five steps of 0·002 mho each. Each set has its members brought to a switch which, by the rotation of a hand-wheel, joins the desired number of coils in parallel one after the other. In this manner any current up to 111 amperes can be obtained by steps of 0·2 ampere.

It may be well to give a few details respecting those coils and switches.

of coils in parallel, and there is none of the annoyance experienced when a number of separate switches are used and an effort of memory has to be made to remember which switches allow the desired current to pass; moreover, at full load there is no idle wire. The switch for the one-ampere set is similar, but, of course, has only six contacts. The three sizes of switch are shown in Figs. 14, 15, and 16. It will be seen that the details vary slightly, but all are provided with brass eyes, into which the leads are sweated.

Ferranti-Wright meters are provided with an identical set of resistances and switches.

The Frager meter testing circuit has resistances having a conductivity of 22·2 mhos, the finest adjustment being 0·004 mho instead of 0·002. Only the third set is wound on zinc cylinders, the other two being of bare wire on wrought-iron frames, and the two-mho set is on two separate frames, having one mho conductivity each.

For the circuit for running the meters on full load, the pressure being only 10 volts, coils having a conductivity of 22·2 mhos are used, the adjustment being by steps of 0·04 mho. These coils are, of course, much shorter than those used with 100 volts pressure, but are mounted in the same general way.

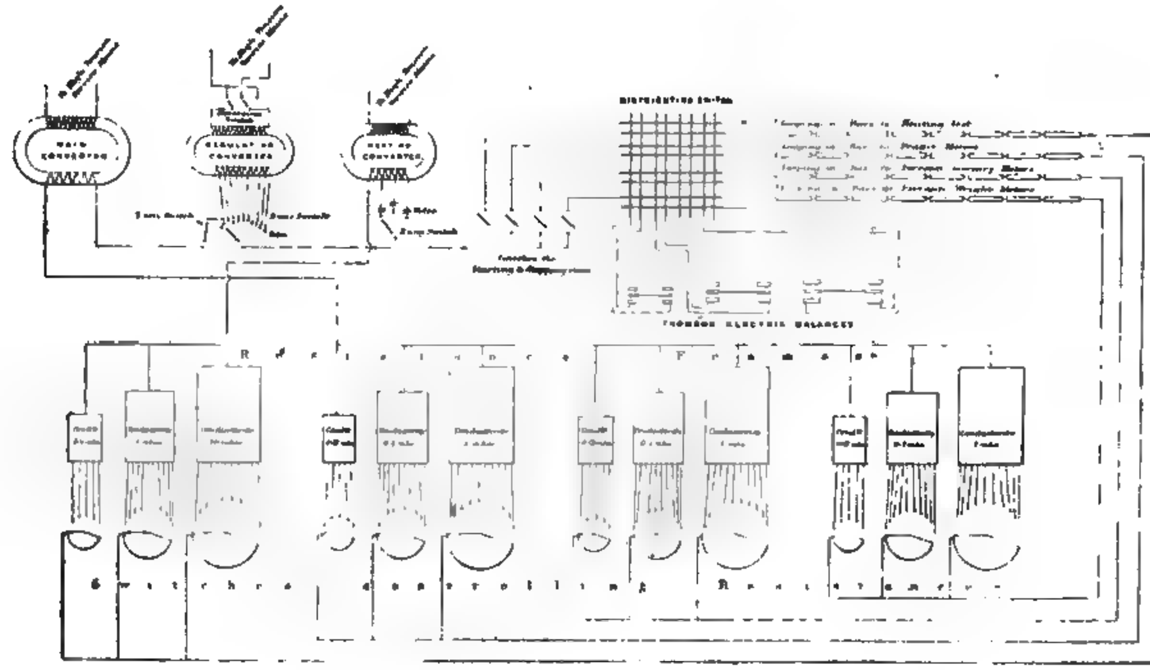

Fig. 18.

Coils.—All the wires are of platinoid, and the diameter in no case exceeds 1½ millimetre, the object being to allow them to attain their final temperature rapidly. The coils that have to carry 10 amperes are of No. 17 B.W.G. bare platinoid wire, and are wound in two parallel oppositely-directed spirals carried on circular brown porcelain insulators, through which are passed bolts fixed to a light wrought-iron frame. The spirals are steadied by passing over two intermediate sets of insulators. Fig. 13 shows the arrangement. The other two sets of coils are wound on zinc cylinders about 3½in. in diameter, split parallel to their axes to eliminate eddy currents, and each spiral is wound half in one direction and half in the other.

Switches.—Those for the 100-ampere and the 10-ampere coils have each 11 ring contacts, projecting inwards radially round a semicircle. The first contact is of sufficient size to carry the whole current of the set of coils to which it belongs, while the other 10 are in each case adapted to the current that flows through each member of the set. A brass sector, worked by a hand-wheel insulated from it, subtending the same angle at the centre of the switch as the 11 contacts, is so placed that when the hand-wheel is moved continuously in one direction, it is forced successively through all the ring contacts, thus connecting the 10 one after the other with the first. The position of the handwheel thus determines the number

With the exception of the last-named circuit, all are fed from an ordinary Ferranti 40-h.p. converter, transforming from 2,400 volts to 100 volts, and therefore giving about 300 amperes in its secondary. This current is sufficient, since it is easy to so arrange the runs that it is not exceeded. There is a certain amount of drop of pressure at full load, even in this type of converter, which is exceptionally good in this respect, and the ordinary high-tension service mains being used, the pressure cannot always be relied upon to be exactly 100 volts. In order to obtain a constant pressure, the author employs a subsidiary regulating converter, having its secondary in series with the main converter; it transforms down from 2,400 volts to 9½ volts, and will yield 300 amperes in its secondary. Connection can be made at 10 points of its secondary, so as to obtain the current at a pressure of ½, 1½, 2½, to 9½ volts. By means of one two-way and one ten-way switch, the pressure can be varied 9½ volts (see Fig. 18). In the primary is a reversing switch, so that this converter can either help or oppose the main. In this way a regulation of 9½ volts either way, or range of 19, is obtained. This, of course, is unnecessarily large, but it was designed for use when the Deptford works were still in a more or less experimental stage, and the large margin was very useful.

The current is measured by Lord Kelvin's standard balances, of which there are three, one reading nominally to

10 amperes, but actually to six amperes (getting very hot even with this if the current is on for any length of time), one reading to 100 amperes and the third to 600 amperes. All these are required on each testing circuit, though only one at a time; in order, therefore, to render any one available for all circuits a switch is employed, consisting of two sets of bars running at right angles to one another, on opposite sides of a slab of slate. At alternate points of crossing, holes are drilled through bars and slate, being tapped in those at the back, and allowing brass bolts provided with insulating handles to pass through the front bars and the slate. These bolts have each a collar which takes a bearing on the front bar when the bolt is screwed into the back, thus connecting the bars. By means of two such bolts any two vertical bars, to which are connected the balances, can be joined to any two horizontal bars, to which are brought the circuits. Two spare vertical bars or "bridges," with holes drilled at every point of intersection, take the place of the balance in the circuit without one (usually the heating circuit), and admit of changing from one balance to another without stopping the run. This switch is shown in Fig. 17.

The circuit is never broken with the plugs. A single-break "pointsman" switch is placed in each circuit, and admits of runs being started and stopped in any one circuit independently of the others.

The number of meters of any kind required to be tested at once is constantly varying, and if two fixed terminals only are provided between which to join them, a number of different lengths of cable for connecting them thereto are required; these are clumsy and unsightly, and the following has been found to be a convenient device. A series of brass bars, about 2ft. 6in. long, having bolts and nuts projecting at intervals of 8in. or 9in., are fixed on teak against the wall above the shelf on which the meters stand: bridging-pieces serve to bridge across the gaps when required. Short pieces of very flexible cable, terminating in brass eyes, are used to join the ends of a set of meters to the nearest bolts of separate bars. On removing the bridging-piece connecting the bars, the meters are looped in. Another advantage of this is that a second batch of meters can be got ready at another part of the shelf while the first are running.

Fig. 18 shows diagrammatically the arrangement of the whole testing plant described above.

EXPERIMENTS WITH ALTERNATE CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY.*

BY NIKOLA TESLA.

(Concluded from page 595.)

Another line of experiment, which has been assiduously followed, was to induce by electro-dynamic induction a current or luminous discharge in an exhausted tube or bulb. This matter has received such an able treatment at the hands of Prof. J. J. Thomson that I could add but little to what he has made known, even had I made it the special subject of this lecture. Still, since experiences in this line have gradually led me to the present views and results, a few words must be devoted here to this subject. It has occurred, no doubt, to many, that as a vacuum tube is made longer the E.M.F. per unit length of the tube necessary to pass a luminous discharge through the latter, gets continually smaller: therefore, if the exhausted tube be made long enough, even with low frequencies a luminous discharge could be induced in such a tube closed upon itself. Such a tube might be placed around a hall or on a ceiling, and at once a simple appliance capable of giving considerable light would be obtained. But this would be an appliance hard to manufacture and extremely unmanageable. It would not do to make the tube up of small lengths, because there would be with ordinary frequencies considerable loss in the coatings, and, besides, if coatings were used it would be better to supply the current directly to the tube by connecting the coatings to a transformer. But even if all objections of such nature were removed, still, with low frequencies the light conversion itself would be inefficient, as I have before stated. In using extremely high frequencies the length of the secondary—in other words, the size of the vessel—can be reduced as far as desired, and the efficiency of the light conversion is increased, provided that means are invented for efficiently obtaining such high frequencies. Thus one is led, from theoretical and practical considerations, to the use of high frequencies, and this means high E.M.F.'s and small currents in the primary. When he works with condenser charges—and these are the only means up to the present known for reaching these extreme frequencies—he gets to E.M.F.'s of several thousands of volts per turn of the primary. He cannot multiply the electro-dynamic inductive effect by taking more turns in the primary, for he arrives at the conclusion that the best way is to work with one single turn—though he must sometimes depart from this rule—and he must get along with whatever inductive effect he can obtain with one turn. But before he has long experimented with the extreme frequencies required to set up in a small bulb an E.M.F. of several thousands of volts, he realises the great importance of electrostatic effects, and these effects grow relatively to the electro-dynamic in significance as the frequency is increased. Now, if anything is desirable in this case, it is to increase the frequency, and this would make it still worse for the electro-dynamic effects. On the other hand, it is easy to exalt the electrostatic action as far as one likes by taking more turns on the secondary, or combining self-induction and capacity to raise the potential. It should also be remembered that, in reducing the current to the smallest value and increasing the potential, the electric impulses of high frequency can be more easily transmitted through a conductor.

These and similar thoughts determined me to devote more attention to the electrostatic phenomena, and to endeavour to produce potentials as high as possible, and alternating as fast as they could be made to alternate. I then found that I could excite vacuum tubes at considerable distance from a conductor connected to a properly constructed coil, and that I could, by converting the oscillatory current of a condenser to a higher potential, establish electrostatic alternating fields which acted through the whole extent of a room, lighting up a tube, no matter where it was held in space. I thought to recognise that I had made a step in advance, and I have persevered in this line; but I wish to say that I share with all lovers of science and progress the one and only desire—to reach a result of utility to men in any direction to which thought or experiment may lead me. I think that this departure is the right one, for I cannot see, from the observation of the phenomena which manifest themselves as the frequency is increased, what there would remain to act between two circuits conveying, for instance, impulses of several hundred millions per second, except electrostatic forces. Even with such trifling frequencies the energy would be practically all potential, and my conviction has grown strong that, to whatever kind of motion light may be due, it is produced by tremendous electrostatic stresses vibrating with extreme rapidity. Of all these phenomena observed with currents, or electric impulses, of high frequency, the most fascinating for an audience are certainly those which are noted in an electrostatic field acting through considerable distance, and the best an unskilled lecturer can do is to begin and finish with the exhibition of these singular effects. I take a tube in the hand and move it about, and it is lighted wherever I may hold it; throughout space the invisible forces act. But I may take another tube and it might not light, the vacuum being very high. I excite it by means of a disruptive discharge coil, and now it will light in the electrostatic field. I may put it away for a few weeks or months, still it retains the faculty of being excited. What change have I produced in the tube in the act of exciting it? If a motion imparted to the atoms, it is difficult to perceive how it can persist so long without being arrested by frictional losses, and if a strain exerted in the dielectric, such as a simple electrification would produce, it is easy to see how it may persist indefinitely, but very difficult to understand why such a condition should aid the excitation when we have to deal with potentials which are rapidly alternating.

Since I have exhibited these phenomena for the first time, I have obtained some other interesting effects. For instance, I have produced the incandescence of a button, filament, or wire enclosed in a tube. To get to this result it was necessary to economise the energy which is obtained from the field and direct most of it on the small body to be rendered incandescent. At the beginning the task appeared difficult, but the experiences gathered permitted to reach the result easily. In Fig. 34 and Fig. 35 two such tubes are illustrated which are prepared for the occasion. In Fig. 34 a short tube, T_1, sealed to another long tube, T, is provided with a stem, *s*, with a platinum wire sealed in the latter. A very thin lamp filament, *l*, is fastened to this wire, and connection to the outside is made through a thin copper wire, *w*. The tube is provided with outside and inside coatings, C and C_1 respectively, and is filled as far as the coatings reach with conducting, and the space above with insulating powder. These coatings are merely used to enable to perform two experiments with the tube—namely, to produce the effect desired either by a direct connection of the body of the experimenter or of another body to the wire, *w*, or by acting inductively through the glass. The stem, *s*, is provided with an aluminium tube, *a*, for purposes before explained, and only a small part of the filament reaches out of this tube. By holding the tube T_1 anywhere in the electrostatic field the filament is rendered incandescent. A more interesting piece of apparatus is illustrated in Fig. 35. The construction is the same as before, only instead of the lamp filament a small platinum wire, *p*, sealed in a stem, *s*, and bent above it in a circle, is connected to the copper wire *w*, which is joined to an inside coating, C. A small stem, s_1, is provided with a needle, on the point of which is arranged to rotate very freely a very light fan of mica, *v*. To prevent the fan from falling out, a thin stem of glass, *g*, is bent properly and fastened to the aluminium tube. When the glass tube is held anywhere in the electrostatic field the platinum wire becomes incandescent, and the mica vanes are rotated very fast.

* Lecture delivered before the Institution of Electrical Engineers at the Royal Institution, on Wednesday evening, February 3, 1892. From the *Journal* of the Institution of Electrical Engineers.

Intense phosphorescence may be excited in a bulb by merely connecting it to a plate within the field, and the plate need not be any larger than an ordinary lamp shade. The phosphorescence excited with these currents is incomparably more powerful than with ordinary apparatus. A small phosphorescent bulb, when attached to a wire connected to a coil, emits sufficient light to allow reading ordinary print at a distance of five to six paces. It was of interest to see how some of the phosphorescent bulbs of Prof. Crookes would behave with these currents, and he has had the kindness to lend me a few for the occasion. The effects produced are magnificent, especially by the sulphide of calcium and sulphide of zinc. From the disruptive discharge coil they glow intensely merely by holding them in the hand and connecting the body to the terminal of the coil.

To whatever results investigations of this kind may lead, their chief interest lies for the present in the possibilities they offer for the production of an efficient illuminating device. In no branch of electric industry is an advance more desired than in the manufacture of light. Every thinker, when considering the barbarous methods employed, the deplorable losses incurred in our best systems of light production, must have asked himself, What is likely to be the light of the future? Is it to be an incandescent solid, as in the present lamp, or an incandescent gas, or a phosphorescent body, or something like a burner, but incomparably more efficient? There is little chance to perfect a gas burner; not perhaps, because human ingenuity has been bent upon that problem for centuries without a radical departure having been made—though this argument is not devoid of force—but because in a

FIG. 34.—Tube with Filament Rendered Incandescent in an Electrostatic Field.

FIG. 35.—Crookes Experiment in Electrostatic Field.

burner the higher vibrations can never be reached except by passing through all the low ones. For how is a flame produced unless by a fall of lifted weights? Such process cannot be maintained without renewal, and renewal is repeated passing from low to high vibrations. One way only seems to be open to improve a burner, and that is by trying to reach higher degrees of incandescence. Higher incandescence is equivalent to a quicker vibration: that means more light from the same material; and that, again, means more economy. In this direction some improvements have been made, but the progress is hampered by many limitations. Discarding, then, the burner, there remains the three ways first mentioned, which are essentially electrical. Suppose the light of the immediate future to be a solid rendered incandescent by electricity. Would it not seem that it is better to employ a small button than a frail filament? From many considerations it certainly must be concluded that a button is capable of higher economy, assuming, of course, the difficulties connected with the operation of such a lamp to be effectively overcome. But to light such a lamp we require a high potential; and to get this economically we must use high frequencies. Such considerations apply even more to the production of light by the incandescence of a gas, or by phosphorescence. In all cases we require high frequencies and high potentials. These thoughts occurred to me a long time ago.

Incidentally we gain, by the use of very high frequencies, many advantages, such as a higher economy in the light production, the possibility of working with one lead, the possibility of doing away with the leading-in wire, etc. The question is, How far can we go with frequencies? Ordinary conductors rapidly lose the facility of transmitting electric impulses when the frequency is greatly increased. Assume the means for the production of impulses of very great frequency brought to the utmost perfection, everyone will naturally ask how to transmit them when the necessity arises. In transmitting such impulses through conductors, we must remember that we have to deal with pressure and flow, in the ordinary interpretation of these terms. Let the pressure increase to an enormous value, and let the flow correspondingly diminish, then such impulses—variations merely of pressure, as it were—can no doubt be transmitted through a wire even if their frequency be many hundreds of millions per second. It would, of course, be out of question to transmit such impulses through a wire immersed in a gaseous medium, even if the wire were provided with a thick and excellent insulation, for most of the energy would be lost in molecular bombardment and consequent heating. The end of the wire connected to the source would be heated, and the remote end would receive but a trifling part of the energy supplied. The prime necessity, then, if such electric impulses are to be used, is to find means to reduce as much as possible the dissipation. The first thought is, employ the thinnest possible wire surrounded by the thickest practicable insulation. The next thought is, to employ electrostatic screens. The insulation of the wire may be covered with a thin conducting coating, and the latter connected to the ground. But this would not do, as then all the energy would pass through the conducting coating to the ground, and nothing would get to the end of the wire. If a ground connection is made, it can only be made through a conductor offering an enormous impedance, or through a condenser of extremely small capacity. This, however, does not do away with other difficulties. If the wave-length of the impulses is much smaller than the length of the wire, then corresponding short waves will be set up in the conducting coating, and it will be more or less the same as though the coating were directly connected to earth. It is, therefore, necessary to cut up the coating in sections much shorter than the wave-length. Such an arrangement does not still afford a perfect screen, but it is ten thousand times better than none. I think it preferable to cut up the conducting coating in small sections, even if the current-waves be much longer than the coating. If a wire were provided with a perfect electrostatic screen, it would be the same as though all objects were removed from it at infinite distance. The capacity would then be reduced to the capacity of the wire itself, which would be very small. It would then be possible to send over the wire current-vibrations of very high frequencies at enormous distances without affecting greatly the character of the vibrations. A perfect screen is of course out of question, but I believe that with a screen such as I have just described telephony could be rendered practicable across the Atlantic. According to my ideas, the guttapercha-covered wire should be provided with a thin conducting coating subdivided in sections. On the top of this should be again placed a layer of guttapercha and other insulation, and on the top of the whole the armour. But such cables will not be constructed, for ere long intelligence — transmitted without wires — will throb through the earth like a pulse through a living organism. The wonder is that, with the present state of knowledge and the experiences gained, no attempt is being made to disturb the electrostatic or magnetic condition of the earth, and transmit, if nothing else, intelligence. It has been my chief aim in presenting these results to point out phenomena or features of novelty, and to advance ideas which I am hopeful will serve as starting points of new departures. It has been my chief desire this evening to entertain you with some novel experiments. Your applause, so frequently and generously accorded, has told me that I have succeeded.

In conclusion, let me thank you most heartily for your kindness and attention, and assure you that the honour I have had in addressing such a distinguished audience, the pleasure I have had in presenting these results to a gathering of so many able men—and among them also some of those in whose work for many years past I have found enlightenment and constant pleasure—I shall never forget.

Nickel-plating.—A volatile compound of nickel has been discovered by M. Mond, obtained by passing carbonic oxide over nickel reduced by hydrogen. The body, which has been named nickel tetracarbonyle, is dissolved in large quantity in petroleum. Such a solution can be used to nickel-plate wires. M. Rigaud has succeeded in nickel-plating copper wire in the following manner: The wire is uncoiled from a bath of the nickel liquid on two metallic cores connected to a dynamo, from which a current is passed sufficient to heat the wire to about 90deg. or 100deg. C. At this temperature the nickel tetracarbonyle is decomposed and the metal is deposited, giving an adherent deposit. The process seems to open further possibilities to the application of nickel-plating.

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ROYAL AGRICULTURAL SHOW AT WARWICK.

Electrical engineers are not much concerned with agricultural shows, but who knows what time will do to change these conditions? The experiments of the late Dr. Siemens and others to obtain direct information about the action of electricity on plant cultivation, have not given sufficiently practical results to induce agriculturists to adopt any of the proposed electrical methods. We are inclined to the opinion that what may be termed the method to force Nature's action, will never come into general practical use. Upon a small scale for luxurious purposes forcing may be adopted, but it has not been conclusively proved that electricity is of much use even under these conditions. It may be asked, then, what has an agricultural show, even if it be a Royal show, to do with electrical matters? It is an answer to such a query we wish to consider. Primarily, agricultural shows are to encourage the better breeding of all kinds of live stock, the better management of arable and pasture land, so as to increase the return in crops in proportion to the labour expended. Gradually one branch of these shows has developed till it almost equals in interest the branch more intimately in the popular mind connected with such shows—we refer to the implement and machinery part of the show. Without entering into detail, it is due to the exertions of the Royal Agricultural Society that portable engines are perfected to the extent they are. In years gone by the competitions for the society's prize were keen, and it was a prize eagerly sought after. This eagerness led makers to study each detail in construction, and economy in fuel became greater and greater. Similar conditions ruled, and rule, in other classes of machinery, and the society's prizes for new exhibits leads manufacturers to send to the show. Now, one important factor in the development of the use of electricity for lighting private mansions is the provision of simple inexpensive power motors. In many instances steam is unavailable. In other instances gas is unobtainable; it is impossible to connect to ordinary gas works, or to manufacture by the Dowson process. Hence, in numberless cases, moneyed men at home and abroad were unable to instal the light they so much admired. To remedy this want, attempts were made to use the cheap heavy oils so common in various parts of the world, and fairly easily obtainable everywhere. It was soon seen that a good gas motor would obtain a very extensive sale, and a walk through the machinery department of this year's show at Warwick will have convinced the most sceptical that oil engines have come to stay. There is but one objection to them, and that is the at present seeming impossibility of getting rid of the smell. On the other hand, several makers guarantee engines of high efficiency. It is to be hoped that the society will institute a competition in this department, then we shall know exactly what the engines will do. We say "hope," because at present the development of oil engines seems to appeal less to agriculturists than to electrical engineers. When, however, we find firms of so vast

experience as Crossley's, Tangye's, Hornsby's, and others, devoting special attention to these engines, we may be sure that such firms will not place an engine upon the market that would detract from their high and well-deserved reputation. As we say, the prevailing feature of the Warwick Show is the number of oil engines. Few other exhibits of an electrical character were to be found, though of course the excellent steam engines exhibited by all the leading makers present features of interest to electrical engineers. It is becoming common now to see the words "as specially constructed for electric lighting" applied to engines, especially to undertype engines of the semi-portable class. Two firms exhibited magnetic separators, though we should be inclined to give the palm to that of the Hardy Patent Pick Company, in which the iron is subjected to run the gauntlet from a number of magnets. This machine was, however, exhibited last year at Doncaster and described by us at the time.

WESTERN COUNTIES, ETC., TELEPHONE AMALGAMATION.

This amalgamation is a natural proceeding. The local company was an offshoot of the London company, and the latter always held a controlling interest. As soon, then, as it became expedient for the National to resume possession it has done so. The mere fact that its shares were not used in the voting is immaterial. The holders of the shares that did vote were really its nominees and friends, whose interests are more bound up with the policy of the National than with that of the local company. The National is concentrating its forces for the fight against the Government and possible competitors. When practically the whole working telephone interests are controlled in Oxford Court they imagine there can be no divergent opinions assisting antagonists, otherwise it is difficult to understand the latest move. The ostensible reason for the amalgamation was want of money, but according to those who were against amalgamation the requisite money could without much difficulty have been found. In our estimation the policy of the National is a wrong one, and they seem to court disaster even when with all the cards in their hands they might almost play their own game. Had they a number of successful local companies and a good sprinkling of local shareholders, each small company would have far more interest locally than when all the wires are pulled from Oxford-court. Local politicians would be somewhat loth to interfere with local interests, and the Government proposals would receive far more attention than they will at present. Of course, it is a great thing to say, practically we are the only telephone company in existence. Men are so apt to forget that the controllers of a monopoly cannot well have competitors, and that when the monopoly lapses it takes time to bring other workers into the field. Our advice to the National would long ago have been to multiply local companies and keep a controlling influence. This, combined with a cheap and efficient service, would have prevented competition.

REVIEWS.

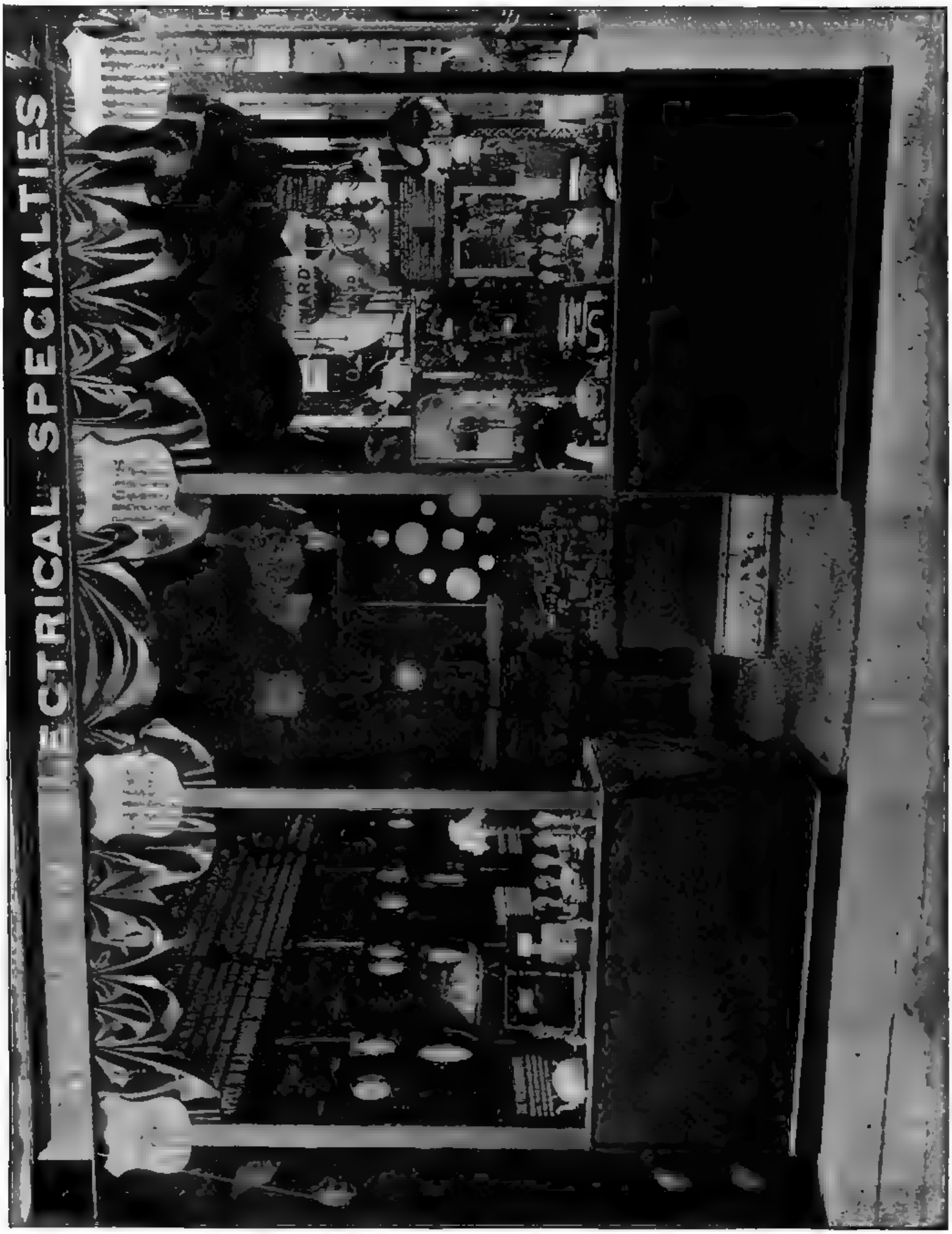
Continental Electric Light Stations, with Notes of the Actual Practice for Distributing Electricity in Towns. By KILLINGWORTH HEDGES, M.I.C.E. London: E. and F. N. Spon.

In the early days of an industry everyone engaged in it likes to know what everyone else is doing. There is no fashion, there are no schools. As time goes on there is a gradual weeding out of systems till a few are left, each of which is about as good as its neighbour, and only a long, sometimes a very long, experience can decide which is or which are the fittest to survive. Around these few systems fashion rages, schools are founded, and one side holds it *anathema maranatha* to disagree with their view. It is so electrically. In this book the experience gathers around the two schools—high and low pressure. Some 18 stations illustrative of the former are described, and half as many again of the latter, showing at any rate that for the time being wherein the numerical advantage rests. Mr. Hedges has set himself the task of getting together more or less lengthy descriptions of continental lighting stations, and, by the aid of numerous large and clear illustrations, the compiler is enabled to give his readers a fair idea of the practice throughout the Continent. The work is divided into three sections—the first dealing with high-pressure stations, the second with low-pressure, while the third is a miscellany giving descriptions, opinions, statistics, and tables. We imagine such a book as this is an important factor in the equipment of the engineer who has to design central stations, for from the numerous diagrams and illustrations he is able to see the arrangements adopted at a great variety of stations. In many instances, too, plans are given, from which the distances and areas lighted can be known, all which information assists in the planning of new work. Although a good many figures as to cost are given, these may be liable to misinterpretation, unless a good deal of further information special to the district is known relating to rate of wages, length of working day, and cost of material. Altogether, then, this book forms a compendious collection of material which must prove useful to all engaged in central station work.

THE CRYSTAL PALACE EXHIBITION.

The exhibition at the Crystal Palace can hardly make any serious claim to be an international exhibition, for although the galleries include a few exhibits from abroad, yet the large manufacturers on the Continent are not exhibiting. Of course, those names that have become acclimatised in England are conspicuous enough, such as Siemens, Gulcher, and Richard Frères; and the same may be said about American exhibits, where Brush, Thomson-Houston, and Edison flourish under the flag of their adoption. But one exhibit there is of international interest, embodying quite a large number of interests of American manufacturers—that of **Mr. W. J. Hammer**—in the Machinery Hall. This important exhibit it is all the more necessary to notice specially, as while being rather late in the field it includes one of paramount importance to the electrical engineering profession at large—namely, the H. Ward Leonard system of regulating electric motors by varying separately the currents and pressures in motor the fields and the armature—a system which seems destined to effect a radical change in our methods of motor regulation. Mr. Hammer, it will be remembered, is the enterprising gentleman, at one time chief engineer to the Edison Company in Great Britain and Europe, who organised the effective display of Edison's inventions at the time of the great Paris Exposition of 1889. Mr. Hammer has now an extensive practice of his own, with offices in New York and the Savoy Hotel, London; and besides the Ward Leonard system, he shows, as sole agent in England, the electric cooking appliances on the Carpenter system, now fairly well known to the public by the exhibitions in the Crystal Palace Exhibition itself and elsewhere. Besides these important interests Mr. Hammer also has the agency for and exhibits of the following firms and companies:

First, of the Ries Electric Speciality Company, in the Ries electric lamp regulating socket, which has already been described in this journal (p. 249); second, the Ward Arc Lamp Company, whose arc lamps for burning in parallel on the Pilkington and White meter, one of the simplest and cheapest meters possible to conceive, which we described (p. 486); sixth, Mr. J. D. Bishop, who has a paper-insulated telephone cable, said to be of the lowest self-induction



The Stand of American Specialties at the Crystal Palace, exhibited by Mr. W. J. Hammer, of New York.

ordinary circuit are making a great success in America; third, the Telemeter Company, who have electric measuring and recording instruments for recording almost any variable at any required distance; fourth, the Ries and Henderson method of electric riveting (see p. 344); fifth, known; and seventh, the Weston Electrical Instrument Company's electrical ammeters and voltmeters, very beautifully devised and manufactured specimens of instruments of precision. The foregoing make up a sufficiently important list of novel and interesting exhibits, which we strongly

advise every electrical engineer to carefully inspect before the close of the Exhibition on Saturday, July 2nd.

The Ward Leonard System of Motors.—We have already given some considerable attention to this system, but we ought to mention that for those who wish to have an actual example of the method of connecting the motors advocated by Mr. H. Ward Leonard, a set of apparatus has been erected by Mr. Hammer at his stand. This, although only on a small scale, sufficiently illustrates the mode of connection, while, as for actual experimental tests, we give some interesting figures further on. In this specimen set, three small Crocker-Wheeler motors are connected together to imitate the arrangement advocated. The supply of current is obtained from the Exhibition mains to drive one of the motors. This motor is coupled by a belt to a second motor driven as generator. Such an arrangement makes a motor-generator, and in practice would be in one machine with two armatures in the same field. The current from this generator drives the motor which is to do the work desired, the point being to have this motor work at the highest efficiency at any call upon it—whether the speed be high or low, whether the power absorbed be little or much, the electrical efficiency of the whole arrangement is to be high. This effect is achieved, allowing the transmitted current to go through only the armature of the motor, the field current being obtained from the main supply circuit and varied independently.

We will give the explanation in Mr. Leonard's own words:

In the operation of electric motors there are three principal factors to be considered—the speed, the torque, and the efficiency. Under any variations in power the efficiency should remain as nearly constant as possible. For one class of work it is desirable to keep the speed constant when the torque varies. For a second class of work it is desirable to keep the torque constant at one particular amount when the speed varies. For a third class it is desirable to operate at many different speeds, and yet automatically at any particular speed desired regardless of the torque. For a fourth class it is desirable to operate at many different torques and yet automatically at any desired torque regardless of the speed; and for a fifth kind it is desirable to keep the amount of power supplied constant, regardless of a change in torque—that is, so that if the torque changes by the requirements of practice, the speed would automatically change so that the power consumed would remain constant.

The shunt-wound motor, operating on a constant potential circuit, is well adapted to the first class of work mentioned, where only one fixed speed is desired, practically regardless of the torque and with a practically constant efficiency.

The second class of work mentioned, having one particular constant torque and a speed variable at will, cannot be performed by existing electric motors without great sacrifice of efficiency. In this class of work we find hoists lifting a constant weight, certain printing presses, swing bridges, stamp mills, pumps, etc.—that is, such work as requires that we should start up from dead rest with full torque and run at any desired speed with the same torque and with perfect efficiency.

The third and fourth classes of work are more common than would at first appear evident, but since neither the steam engine nor the waterwheel can be operated under conditions where both speed and torque will vary, and where the speed or torque can be held automatically fixed at any point desired, regardless of variation of the other, we do not find work of this kind existing in such shape as to be operated by an electric motor instead of some other power. Nor has the electric motor been available for such duty heretofore. A familiar instance of the third kind of work is met with in the printing of fabrics, where the presses have a large number of rolls upon which the torque depends, and the speed of the presses must be varied as desired, and yet at any given speed must hold that speed constantly, regardless of the number of rolls set down; that is, regardless of the torque. Similarly, lathes, drill presses, wood-working machinery, etc., belong to this class. Certain variations in the speed are possible by existing methods, by the use of cone pulleys and equivalent devices, but no motor of any kind has heretofore existed which, directly applied, would conform to the requirements of this kind of work.

The fourth kind of work has, as a familiar example, the passenger elevator, where the weight, and, consequently, the torque, is variable, and where at any torque the speed should be controllable at will, with constant efficiency. Another example is the pumping of water against a variable pressure, with the speed controllable at will and independend of the pressure. This result is not obtained directly by any motor to-day.

The fifth class of work, where the speed is automatically varied to keep the power consumed constant, no matter how the torque varies, is not met with in practice as far as I know, yet oftentimes we may have a constant source of power from which we wish to get a torque variable to the requirements of a variable load and do not care particularly about the speed. An electric street railway operated by water power is a familiar example of this class of work.

It will be seen from the above that of the five principal classes of work there is only one—namely, constant speed and variable torque—which we can take care of with reasonable efficiency and from our existing supply circuits.

It is well known that when a street car is first started and is scarcely in motion the actual power represented by such motion is almost nothing, for, although the pounds pull is large, the feet per minute is extremely small; consequently, the power required must be exceedingly small. What do we find in practice? We find that in order to develop a power of but a fraction of a horse-power we must, on account of the slow speed demanded, develop about 30 h.p., and then waste about 98 per cent. of this horse-power in order to utilise the remaining 2 per cent. in the way it is desired. The efficiency of the modern electric street car is not probably more than 2 per cent. when just starting from dead rest and moving at the rate of ½ft. per second.

When we come to investigate this, we find that the explanation is that in order to get the necessary large torque with freedom from excessive sparking, we must have a very large current in a nearly constant field; and since our E.M.F. is constant, we must use an amount of power which will vary almost directly with the torque, and will be regardless of the speed. Or, in other words, the efficiency of the motor will vary directly as the speed with an efficiency of perhaps 80 per cent. at full speed.

As a result of my investigation of this subject I have concluded that the operation of electric motors should conform to what apparently is a new law and which may be stated as follows: Vary the voltage as the speed desired; vary the amperes as the torque required.

In other words, make the speed dependent upon the voltage only and independent of the current, and make the torque dependent upon the current only, and independent of the voltage. Since the product of the speed and torque represents the work being done, and the product of the volts and amperes represents the power supplied, it is evident that if we can operate in conformity to this law, we shall have a constant efficiency under all conditions, disregarding, of course, the small fixed losses in the field and armature.

One way in which this law can be followed is to supply the field of the motor from one source of electric energy and supply the armature from another source, the E.M.F. of which can be varied. It will be noticed that when the speed is fixed, a fixed voltage will be necessary in order to conform to this law, and the shunt motor is found to conform perfectly to the law; but it is the only motor I know of which does conform to the law which seems to be generally applicable.

A simple case will be the operation of a printing press for printing fabrics. Suppose the press has 10 rolls—that is, the torque will vary from 1 to 10 in amount. Suppose also that it must be run at any speed from that represented by 1 to that represented by 20, and at any speed it must hold the speed constantly, and this whether one or ten or any intermediate number of rolls be brought into use. Also that the efficiency must be independent of the speed or torque. In order to conform to this law in a simple way, we will instal a generator and a motor of the

same size, and connect their armatures by two conductors. We will supply their fields from a small separate exciter in the shape of a shunt-wound dynamo. In the circuit leading to the field of the generator we will place a rheostat. If now we drive our generator at a constant speed, the E.M.F. it will produce will depend upon its field, which in turn will depend upon the amount of resistance in the rheostat in its field circuits. The strength of the motor field is constant, being supplied by the constant E.M.F. exciter. Now, evidently the speed of the motor will depend solely upon the E.M.F. supplied to its brushes, and this can be carried from 0 to the maximum limit by varying the rheostat, which will preferably be placed beside the motor itself. The current will automatically vary in proportion to the torque, the speed will vary directly as the voltage, and the efficiency will be constant and independent of the speed or torque.

If we wish to operate an elevator from central station conductors of constant E.M.F., we supply a shunt-wound motor mechanically connected directly with a generator, whose armature is connected to the armature of the elevator motor. The field of the generator is supplied from the central station conductors, but a loop goes up to the elevator car, where a rheostat and reversing switch is placed, so that the E.M.F. of the generator can be varied and reversed at will. The field of the elevator motor is excited from the line constantly.

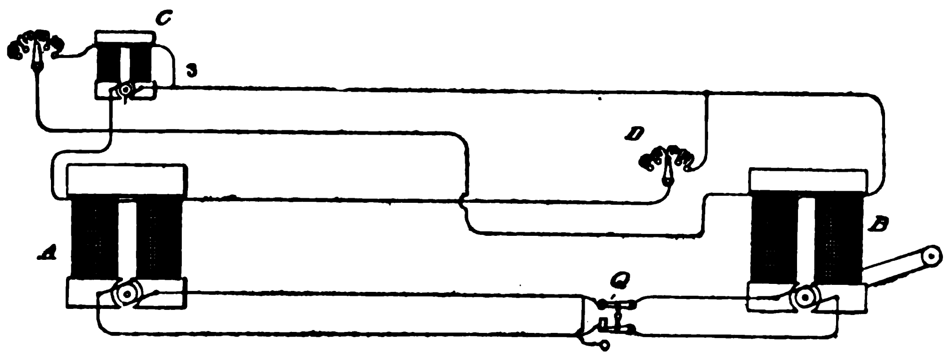
It will be evident that we can control the elevator perfectly from the car and run in either direction, at any desired speed, and with perfect efficiency. It is worthy of notice that the non-sparking point is entirely independent of the speed, and that for any particular weight the non-sparking point is absolutely fixed and independent of the power used. Also that, since the maximum weight alone determines the maximum amperes, it will be impossible to send more than the normal full load in amperes through the armature; consequently the liability of burning out of armatures is reduced to a minimum. The elevator in coming down generates current to assist the central station, and since the efficiency is practically constant under all conditions, and since as many foot-pounds of work are done by the elevator in descending as it requires in ascending, the consumer will in reality pay only for the energy wasted in charging the fields, in heating the armatures, and that represented by the friction of the gearing, which will be the least possible. The starting up of the elevator requires a minimum of power, and hence does not subject the central station to large sudden fluctuations of load.

Suppose we want to operate a swing bridge by an electric motor. We connect as in the case of a printing press, but instead of a hand field rheostat we use an automatic field rheostat, such as is used by the Edison Company. We place an ampere-meter in the armature circuit of our motor, and when the ampere-meter needle indicates full load it touches a contact leading to the relay magnets of the automatic rheostat, which causes it to throw in resistance in the field circuit of the generator and reduces its E.M.F. Similarly, just below full load, the ampere-meter needle makes contact, closing a circuit in the automatic rheostat so as to throw out resistance and raise the E.M.F. of the generator.

To start up the bridge we insert all of our resistance in the field of the generator and have, let us say, no volts. Now we close the main-line switch to the motor; we will have no current; hence the ampere-meter needle will be on the lower contact, which will gradually throw out resistance, and cause the generator to generate an E.M.F. The current will increase, and will finally cause the needle to leave the lower contact. The full torque is now being developed, and the bridge, if the motor be of proper size, will start to move. As it does so, the counter E.M.F. of the motor will tend to reduce the current, but this will cause the needle to again make the lower contact and raise the E.M.F. and speed, and hold the current and torque constant.

Thus, the bridge will start from rest with a minimum of power but full torque, and will gradually accelerate in speed until the full E.M.F. and speed of the motor is reached. To vary the speed by hand we merely move the ampere-meter needle to make either contact desired. In case the bridge should meet an obstruction which would slow it down, the amperes would not increase, but would remain constant, as the volts would be immediately and automatically reduced to just that amount necessary to keep the amperes constant. With this arrangement it will be practically impossible to overload the motor armature.

Another good application of this method of keeping the torque constant will be in any case where a tool is cutting certain material which may vary in hardness or when the feed may vary. If the torque be kept constant it will be impossible to break the cutting tool or injure the apparatus. An electric coal-cutter is a case in point. The cutter may be advancing through slate, fireclay, or coal, and occasionally it will meet a layer of hard-iron pyrites, known in the mines as "sulphur." This may stop the cutter-bar entirely, and with an ordinary, or series or shunt motor, the result would probably be a burnt-out armature. With the system I have described, the current would be constant in any event, and the cutter would automatically go faster in soft material and slower in hard material.



The Ward-Leonard System of Connecting Motors.

In pumping by an electric motor operated on this system, the head alone determines the torque, and hence the current. Consequently, for any lift, the non-sparking point will be fixed, and the number of strokes per minute can be controlled at will from 0 up to the maximum by varying the volts.

For operating an electric railway we will place a shunt-wound motor on the car, and directly driven by this motor will be a special generator, which will be connected to the electric motor below the car. It is evident that the generator and working motor armatures may be wound for any voltage desired—say, 20 volts—which will make the problem of insulating the street-car motor an extremely simple one. If desirable, we can supply several cars of a common train from one special generator on the forward car. With this outfit we will be able to take any car up any practicable grade or around any curve with no more power than is required to move the car on a level, and always consume the same power, regardless of weight, grades, or curves. That is, the automatic increase of current, to take care of any increased torque, will be compensated for by a corresponding decrease in the volts and speed. We may start a car up on any grade or curve with but a small fraction of the power required for normal speed on a level.

I wish to call attention to a very important development leading out from this—namely, that we will be able to use alternating currents for operating our street cars, for it is

well known that the ordinary alternating-current generators will operate perfectly as motors, if the speed and torque be kept constant. Since by this system we can, from a constant torque and speed, get any other torque and, automatically, a corresponding speed, we shall be able to run street cars perfectly by alternating currents. This, again, will enable us to dispense with trolleys, conduits, storage batteries, etc. We will place between our tracks, in manholes, converters whose primary pressure can be anything required for proper economy and whose secondary will be, say, 15 volts. This secondary circuit will connect directly with the rails. The road will be divided in sections, each a few hundred feet long, and each section will be supplied by its own converter.

This system also lends itself very readily to the transmission of power. We may transmit by alternating currents, and the alternating-current motor running at a constant speed and at a nearly constant torque will drive special generators to operate hoists, pumps, locomotives, etc., at the varying torques and speeds demanded by practice, and yet without subjecting the alternating-current motor to a sudden or wide fluctuation in its torque and without any necessity of varying its speed. With this system of operating electric motors there seems to be no work met with in practice which cannot be perfectly performed.

On first consideration, the additional apparatus necessary would seem to make the system prohibitory in practice; but the capacity of the present single motor is greater than the combined capacity of the apparatus this system would require, and the capacity of the prime motor is very much reduced.

In order to reduce the first cost to a minimum, and yet secure the advantages of different automatic speeds and high efficiency, I have devised two modifications of the arrangement described above. The first is adapted to power in which a smooth, efficient acceleration of a load from rest is required, as in the case of passenger locomotives and elevators. The second case is where various automatic speeds are desired, but no especial importance attaches to the starting of the load from rest, as is the case in machinery in general.

For the first case we have the trolley system of electric street cars as the most important. Let us suppose we have two motors of 15 h.p. each for the car. We find that for full speed upon a level we require about 15 amperes at 500 volts. Upon heavy grades we find that about 50 amperes are required and, as before, we have 500 volts. With this consumption of energy we find that we get a speed upon the heavy grade which is about one-quarter of the speed upon a level. In order to operate upon my system, let us place upon the car a motor-generator, the motor part of which is wound for 500 volts and 12½ amperes, and the generator part of which is wound for 125 volts and 50 amperes. The fields of the motor and generator part are distinct, and are wound for 500 volts, as are the fields of the two propelling motors under the car. All these fields are supplied from the 500-volt trolley circuit. In the field of the auxiliary generator is placed a rheostat.

Now, suppose the car at rest upon a grade. The motor generator is running, but the generator has a very weak field. Its armature is connected by a controlling switch to the propelling motors. We now gradually cut out resistance from the generator field circuit, and finally get about 20 volts at the brushes of the generator. With this E.M.F. we get sufficient current to produce 50 amperes through the armatures of the propelling motors in a saturated field. This gives us the full torque, and the car starts at a speed of perhaps half a foot a second. This speed can be maintained constantly and indefinitely, and the consumption of energy will be less than 2 h.p. This is less than three amperes from the trolley line. In practice, however, the speed will be rapidly but gradually accelerated until we have 125 volts upon the terminals of the propelling motors. We will now be running at one-quarter speed and will be consuming 125 volts and 50 amperes; that is, 6¼ kilowatts instead of 25 kilowatts to get the same result with existing motors. To put it another way, we will not be using as much energy as is represented by the 500 volts and 15 amperes necessary for full speed on a level.

The next step on the controlling switch will disconnect the armatures of the propelling motors from the auxiliary generator and put the two armatures in series across the trolley line direct. We will now go at a speed represented by 250 volts; that is, one-half full speed. The next step of our switch will place the two armatures in multiple across the 500 volts, and the next and last step will place the 120-volt auxiliary generator in series with the main central station generators, and give us 625 volts on our armatures and a correspondingly increased speed. We will be able to go up a grade of 6 to 8 per cent. at full speed, with 50 amperes and 500 volts, which, with the present motors, gives us only about one quarter of that speed.

Under this arrangement it will be noticed that the only apparatus which could be called additional is the small motor of 500 volts for the generator part of our motor-generator, which is useful not only for starting but for full speed also. In stopping the car we have an electric brake action delivering back energy to the line at full efficiency, and not through a rheostat, as at present.

If we have a train of, say, three cars, so that we have six motors, we can start from rest with sufficient smoothness by placing all six armatures in series, which will give us something less than one-sixth speed as the first step. Then we can place three in series with two multiples, which gives us one-third speed. Next, two in series with three multiples, which gives us one half speed, and finally all in multiple, which gives us full speed. Under such conditions, we can dispense with the small converting plant altogether.

For an elevator requiring, say, 15 h.p. we will put in a motor-generator of 3 h.p., with which we will control the starting and stopping and the operation up to one-fifth of full speed. Then for full speed we will connect direct to the line and operate without any conversion of energy.

For power in which smoothness of motion in starting and stopping is not essential I have devised a new system of distribution as follows: Three dynamos, all having the same current capacity, and having voltages of 62½, 125, and 250 respectively, are placed in series and from conductors led off in multiple one from each terminal of the machines. These conductors will have potentials which can be represented by 0, 62½, 187½, and 437½. Let us now take a shunt-wound motor, and disconnecting the field from the armature circuit, excite the field from the outside two of the four conductors—that is, by an E.M.F. of 437½ volts. By connecting the armature terminals to the four conductors in various ways, we shall be able to operate in either direction at six different automatic speeds represented by the following voltages: 62½, 125, 187½, 250, 275, 437½. By varying the field strength of the motor we can, if required, get any intermediate speed.

In many cases two dynamos will answer, one of, say, 110 volts already in use for incandescent lighting, and a second of, say, 30 volts. With this arrangement we could run in either direction and with automatic speeds represented by 30, 110, and 140.

With the four-wire six-voltage system of distribution in a shop we can take out all countershafting, belting, pulleys and gears, if desired, and place a motor upon every tool, which we can operate in either direction at any automatic speed desired. Lathes, planers, and all tools can be perfectly operated, and by getting rid of all countershafts and belts we can introduce the greatest of modern tools, the travelling crane, which we will also operate from our general system. We can also readily operate ventilating fans, hoists, elevators, and factory tramways from the system.

The addition of one dynamo and one new conductor to any existing three-wire system will probably give all the flexibility required to meet practical conditions of varying speeds. For the alternating system a synchronous motor driving our three continuous-current generators will give us the four-wire system in any distant factory or town. For 500-volt street railway circuits a small motor-generator plant for the slow speeds and a direct connection for full speeds will give us perfect results. For storage battery work we have the most perfect condition, as we can get any E.M.F. desired, with a corresponding speed while keeping the field separately excited.

Now that we have the rotary field at command, I think I may safely assert that the time is not far distant when we shall have transformers which will, without motion, convert an alternating current in the primary into a continuous in the secondary; and this seems to me to be the ideal system of the future—that is, one in which energy will be transmitted by alternating currents of constant E.M.F. transformed, without motion, into continuous currents for use at the translating devices and used where motors are concerned, in conformity with the law of efficiency for motors: Vary the voltage as the speed desired; vary the amperes as the torque required.

A very broad patent has been granted to Mr. H. Ward Leonard in America, No. 463,802, dated November 24, 1891, with 26 claims. It will suffice to quote a few of the claims:

1. The method of operating and regulating an electric motor, consisting in maintaining the strength of its field magnet and the position of its commutator brushes constant and altering its speed by varying the E.M.F. supplied to its armature.

5. The method of performing work by the use of electric energy, which consists in varying the E.M.F. in proportion to the "foot" element of the foot-pounds per second of the power required and varying the current in proportion to the "pounds" element.

8. The combination of an electro-dynamic motor, a source of supply for its armature, a separate constant source of supply for its field magnet, and means for varying the potential of the armature-supplying source, located at the point of work performed.

12. The combination, with a wheeled vehicle, of an electric motor mounted thereon to propel the same, said motor having its armature and field magnet energised by separate circuits, and means on the vehicle for varying the E.M.F. of the energy supplied to the armature of said motor.

24. The combination of a source of alternating current of high tension, means for converting such current into a continuous current of lower tension, and a motor having its armature supplied by such continuous current, and its field magnet separately excited.

26. The method of transforming the energy of a prime motor at any speed into propelling energy at any desired speed, which consists in operating an electrical generator by said prime motor, supplying the armature of an electric motor running in a constant field from said generator, and varying the E.M.F. of said generator to vary the speed of said electric motor.

It will be interesting to give some idea of the status in America of the applications of Mr. Ward Leonard's method of motor control, and the following account of its progress will prove, better than anything else that can be said, what prospects are likely to lie before it in this country. Mr. Leonard has recently executed licenses with Messrs. William Sellers and Co., who are one of the largest machine houses in the States, and who build travelling cranes and various other kinds of heavy machinery. They are at present equipping a 50-ton crane with the system, which is now probably in operation. They have in their own works a 5-h.p. jib crane operated on this method, and have avowed themselves much gratified with its performance. They are also making application of the method to the operation of a very large drilling machine, which must be run at various speeds and in either direction. This large machine at present requires a considerable number of gears, and a great deal of controlling mechanism, all of which is to be removed and replaced by a motor on the Leonard system, which will enable them to operate at any speed desired, automatically under various loads, and in either direction. The motor for this crane is 5 h.p., and the particular point to notice is that the entire control will be by one lever only upon the tool itself. They also expect to equip a very large lathe which is used for marine work. The lathe is an extremely large one, and the man in charge rides along on the carriage. The cone pulleys and gearing at present in use occupy a very large amount of space, the largest cone being about 7ft. in diameter and the nest of cone pulleys being 7ft. long. They intend to run this lathe by a motor controlled on the Leonard method, and one of the greatest conveniences will be due to the fact that the control can be arranged upon the tool carriage and handled by the man there without the necessity of his moving, which is regarded as an important point, as he will be at the point of work, and will control the movements of the machine at that point itself. This firm of Sellers and Co. intend to use the Leonard method upon all cranes they build hereafter, and they state their complete satisfaction with the results they have obtained in practice.

Going to quite another class of work a license has been given to the Bryan-Enholm Company, who sell a primary battery and do a large business in the supply of motors for dental drills and similar apparatus, and they use the Leonard regulation for varying the speed or keeping the speed constant under varying torque.

With reference to elevators and hoists—a field where the system is peculiarly applicable—licenses have been arranged with the Otis, Crane, Stokes-Parrish, Whittier and Hale Elevator Companies. These five companies together do about 80 or 90 per cent. of the entire elevator business of America, and it is a significant fact that all of them have taken a license under the Leonard patents acting jointly for the purpose. They have secured an exclusive license. The Otis Company in New York are making the first move in introducing the apparatus, and they have recently closed contracts for lifts for private residences—one for Mr. John Inman, in Fifth-avenue, New York, and the other for Mr. Pratt, of Brooklyn. In both these cases the elevators will be so arranged as to make it possible to control them from the car and from the outside by a switch at each floor. The first in operation was that of Mr. Pratt at Brooklyn. The Otis Company, have of course, thoroughly tested the elevator in their own works, and have found the results very satisfactory.

The case of the Yale and Towne Manufacturing Company is a typical one. This company have a very large machine works at Stamford, Connecticut, making a speciality of cranes, besides other heavy work. They were, as most people are, at first prejudiced against the method by the apparent complication of the apparatus and the fact that when running from a constant potential source, such as a central station, it is necessary to introduce a motor-generator. After explanations, they sent to New York to investigate the working of the motor, both on a small scale in Mr. Leonard's office, and also in an elevator, which had been running since October last in the station of the Brooklyn Edison Company. This elevator has given perfect satisfaction since the day of starting, and when the chief engineer of the Yale and Towne Company went with Mr. Leonard to see how the motor was working they found that three weeks before work had been started on an artesian well in the basement, and that the rubbish and material from digging the well had been thrown in front of the door leading to the motor-chamber. The superintendent, in taking them down, remarked that he had not seen the motor for some months, but he knew it was running all right from the action of the elevator itself. The condition of affairs showed that the motor had not been attended to for some time, as it had not been possible to open the door. The motor works with self-oiling bearings and requires no attention for long periods of time. The engineer of Yale and Towne was extremely pleased with the action of the motor, and went back to the works having undertaken to close a license. The Morgan Engineering Works, of Alliance, Ohio, have also fitted a 150-ton crane at the Watervliet Arsenal, and if successful they will take a license for future cranes.

A contract has recently been secured for ventilating a very large hotel in New York—"New Netherlands," one of the new Astor hotels. In this hotel will be fixed a considerable number of fans, the largest of which will be 72in. diameter. The order was given to Mr. Leonard on the strength of his ability to vary the speed of the fans at will with exactitude.

With reference to electric railway work, the most important of all its applications, it is interesting to learn that one of the largest concerns in New York who are constructing electric railways is the Jarvis and Conklin Trust and Mortgage Company. They have built very extensive

lines in Ogden (Utah), Kansas City, Augusta, and other places. This company are now about to establish a double-track road of 10 miles, running from Baltimore to an adjoining suburb, and they expect to run a service of trains at 30 miles an hour. The entire cost will be nearly £180,000. Their chief engineer, Mr. Abbott, has investigated the Leonard method, and is so thoroughly well pleased with its possibilities for application to railway traction that he has requested a tender, not only on the existing specification for ordinary methods, but also on the Leonard system. He intends to test the system on a 35ft. car at Kansas City, which is now equipped with two 30-h.p. motors. This same engineer wishes to apply the method to the control of the gates of waterwheels which are supplying power for street railways. At Augusta he has a railway run thus, and it is found extremely difficult to regulate the speed in this plant. It seems that it is necessary to have three men all night and day to do nothing but regulate the wheels, each man taking a shift of eight hours. As can be readily understood—the application of a motor regulated under the Leonard system, with whose direction of rotation will reverse as required, and governed by the pressure from the line itself, actuating a relay to run a small motor, which in turn will move the controlling rheostat—the speed can be maintained exactly at such a point as shall give proper pressure on the line. A great feature in the motor run on this method is that the torque is full and strong, even at the slowest revolution, so that the least change of pressure on the line immediately places in operation a motor at full torque to move the gates and restore the pressure to the required point.

A license is also being arranged with the Edison Company; this is a non-exclusive license, not being for propulsion, elevators. or marine work, but limiting to the use in factories and the operation of machines, but not limited in the case of mining applications. Mr. W. S. Andrews, technical assistant to Mr. Kruesi, of the Schenectady Works of the Edison Company, has been investigating the Leonard system, and is enthusiastic as to its possibilities.

We give below the result of a series of tests made with a 10-h.p. motor regulated in the way described by Mr. Leonard. They are not intended as accurate scientific tests upon the system, but simply as sufficient to give data to judge as to the efficiency of the method.

Experiments with the Ward Leonard System of Varying the Speed of an Electric Motor.

In this system the fields of the motor are excited by a current from a different generator from that which supplies the armature current, and the pressure of the armature current is varied to produce any motor speed that may be required. The pressure of the armature current is varied in two ways: (*a*) By exciting the generator fields with a current from an outside source and varying the pressure of the output by using a rheostat in series with the field. The pressure of the armature current and the speed of the motor vary with the pressure of the generator field current. (*b*) By connecting a number of generators of different potentials in series and carrying conductors from the terminals of each. In this way any required number of currents may be obtained having different pressures. The motor fields are excited from an outside source, and should an intermediate speed be required other than those given by the different "steps," it may be obtained by varying the pressure of the motor field current. To reverse the direction of rotation of the motor, the polarity of the armature current is changed in (*a*) by reversing the fields of the generator; in (*b*) by reversing the motor armature current directly by some suitable switch arrangement.

A 10-h.p. Sprague motor was used throughout the experiments, the load being applied and measured by means of a Prony brake. The field currents were supplied by a No. 32 Edison generator—the motor armature current by a No. 16 Edison generator. The first experiments were conducted by Mr. Leonard—System A—who used in series with the fields of the No. 16 generator a reversing rheostat containing resistance up to 2,500 ohms. Carbon brushes were used, those on the motor being set for right-hand rotation. The motor was designed for a 230-volt current, and under full load required 40 amperes of current. The motor was first run under half load.

Full speed left hand	20 amperes	245 volts
Full speed right hand	22 ,, ...	250 ,,
Slow speed right hand	19 ,, ...	32 ,,
Very slow speed left hand..	20 ,, ...	20 ,,
Slow speed no load............	2 ,, ...	6 ,,
Full speed no load......	3 ,, ...	250 ,,

Reversing quickly at full speed, the current rose to 40 amperes, but fell back at once to 20 amperes, the voltage dropping gradually to 0, and then gradually rising to 245 volts.

A 42in. flywheel was put on the brake shaft, rim 7in. face and 4in. thick, weight of rim about 900lb. To bring the motor thus loaded to dead stop from full speed required 14 seconds; to reach full speed again, 16 seconds; to reverse from full speed to full speed, 23 seconds.

At full load 40 revolutions of motor 25 volts 40 amperes.
,, ,, 15 ,, ,, 25 ,, 40 ,,

No sparking of brushes was noticed during the above experiments.

In starting the motor under full load it was found that the full armature current might be instantly thrown on, up to a pressure of 90 volts, without dangerous sparking of motor brushes. At this pressure, however, the strength of the current required to start the motor ran up to considerably over 100 amperes, remaining there for about two seconds and then rapidly dropping to 40 amperes.

During the experiments, the motor fields were constantly excited by a current of 1¼ amperes, 235 volts difference of potential.

After Mr. Leonard's experiments a series of tests were made to determine the efficiency of the motor at various speeds. The same apparatus were used with the exception of the reversing rheostat, which was replaced by a rheostat of six 16-c.p. incandescent lamps, 110 volts 0·5 ampere, in series with the regular resistance-box of the generator. The lamps were arranged in series in such a way that any one or all of them might be cut out, giving a field resistance varying by steps of from 0 to about 1,400 ohms. The length of the Prony brake lever was 4ft. 6in., diameter of brake pulley 46in., diameter of motor pulley 9in. Motor field current constant at 1¼ amperes, 240 volts, giving a constant loss in the fields of 300 watts, or 13,272 foot-pounds per minute. The first tests were under full load:

Current.		Revs. of motor per minute.	Weight bal. at end of lever. lbs.	Total elec. energy inc. fields. ft.-lbs. per minute.	Received at brake. ft.-lbs. per minute.	Net loss. ft.-lbs. per min.
Amp.	Volts.					
40	17	20	51	43,348	5,638	37,710
40	22	50	56	52,203	15,417	36,786
40	34	120	56½	73,479	40,535	32,944
40	48	215	54¼	98,194	64,710	33,484
40	50	220	53¼	101,812	65,035	36,777
40	206	1,167	51	377,727	326,496	51,231
41	220	1,284	52	402,584	368,970	33,614
40	230	1,230	52	420,250	379,701	40,549

To show the effect of variable pressure in motor fields:

Motor fields. Volts.	Armature Amps.	Armature Volts.	Revs. of motor per min.
240	6	240	1,320
190	7	240	1,600
240	20	54	260
190	23	54	312

To show change of motor speed by System B.—A 120-volt Edison generator was connected in series with a 240-volt Edison generator. The pressure of current from 240-volt machine was varied by throwing a resistance in its field circuit. The motor fields were separately excited with 240-volt current:

Armature current. Amperes.	Armature current. Volts.	Motor revolutions per minute.	
5	122	700	Resistance in 240-volt generator field.
6	152	920	
7	276	1,600	
31	102	580	
31	160	920	
31	266	1,500	
36	300	2,200	Resistance out of 240-volt generator field.
36	292	2,000	

To show the change of motor speed as the load is varied, motor field current 240 volts :

Current. Amperes.	Volts.	Weight balanced. lbs.	Revs. of motor per min.
39	233	48½	1,335
6	241	1½	1,455
20	238	22½	1,390
40	234	48½	1,340
6	238	1½	1,420
21	233	23	1,390
38	236	53	1,380

The Carpenter Electric Heating System.—That the question of electric cooking has this year assumed such an important position in this country is distinctly due to the efforts of the Carpenter Electric Heating Company, which Mr. Hammer represents in this country. This company have works at St. Paul, Minnesota, and have worked out, patented, and constructed a large number of electric heating appliances, which are now being shown at the Crystal Palace. In the Carpenter system a resistance wire is embedded in solid enamel placed on the surface of a metal plate, which can be thus heated and used in a large variety of ways. It is not absolutely necessary to have enamel, as Mr. Carpenter's claim is for the "combination with the plate to be heated, and the resistance of a coating of adhesive enamel, or its equivalent, for securing the resistance to, but insulating from, the said plate." Asbestos, earthenware, clay, or any other material might be used, but Mr. Carpenter particularly uses a special enamel having a coefficient of expansion substantially the same as both plates to be heated and the resistance itself, so as to avoid unequal expansion. Mr. Hammer exhibits a complete collection of the Carpenter heaters, consisting of electric tea kettles, frying pans, pancake pans, saucepans, curling tongs, foot-warmers, sadirons, soldering irons, hat ironers, warming pans, and electric house stoves. The system is further applicable in a very interesting and important way to ordinary electric resistances, such as for tramcars and arc lamps; the ordinary wire resistances are somewhat delicate, but these enamel plate resistances are solid and compact, and can be thrown down or trodden upon without breakage. Further, one of the great losses in tramway work is the loss in resistances, which by these plates may be utilised in warmers.

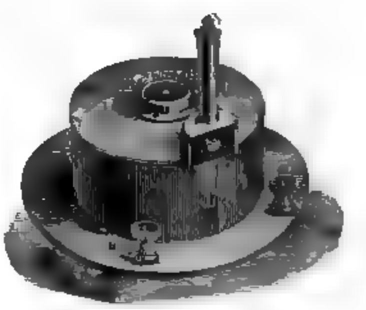
At the Crystal Palace we have had the pleasure of taking a cup of tea for which the water had been boiled by electricity, and, further, had our hat ironed beautifully by an old professional hand, specially engaged by Mr. Hammer, at the Exhibition. His attendants have also cooked chops, boiled eggs, and made pancakes, which have been distributed free of charge to the public.

Weston Electrical Instruments.—Mr. Hammer has, at the Palace, specimens of the Weston electrical instruments, the very set, in fact, that were used by the Technical Committee at the Frankfort Exhibition. These instruments are of a very high degree of finish and accuracy, and they are being used very widely in the States. Although the various electric lighting companies of America have their own type of measuring instruments, we believe that the principal large companies, such as the Thomson-Houston, Westinghouse, and Edison Companies, are all using the Weston instruments. Mr. Weston is now getting out new types of his instruments, which he considers will be far superior even to the present form. He proposes to introduce three separate classes of measuring instruments for both alternate and continuous currents; the first will be a high-class instrument for scientific research work in laboratories; the second class, intended for central station and general expert work; and the third, a cheaper class for rougher testing work, though all will be of high-class workmanship with interchangeable parts. All scales in the Weston ammeters and voltmeters are separately calibrated for each instrument—a very important point, and one sometimes completely ignored by many instrument makers, who often print a scale and attempt to regulate the instrument to the scale. The Weston measuring instruments have a reputation of a very high rank, not only in America, but in Great Britain and on the Continent as well.

Bishop Telephone Cable.—This is a special paper and oil insulated cable. The use of paper insulation in connection with telephone and electric light cables is not new, nor the application of overlapping spirals; yet by a different arrangement of these, Mr. J. D. Bishop produces a vastly superior result. Mr. Bishop, who has had extensive experience both in the construction of cables of various character, and in machinery for manufacturing the same, has found that, when the spirals are wrapped in an open spiral, the air spaces, filled with semi liquid insulation, lower the electrostatic capacity in an extraordinary degree—a feature specially useful for telephone cables.

PROF. AYRTON AND MATHER'S D'ARSONVAL GALVANOMETER.

The general convenience of the class of reflecting galvanometers in which a suspended coil moves in the field of a permanent magnet, proposed by Maxwell, but usually known by the name of D'Arsonval, has brought them into extensive use in the course of the last five years. But, as in the case of many other apparently simple instruments, it is only by paying great attention to details that perfection can be attained. In the instruments under consideration, the length, breadth, and form of cross-section of the coil have important influences on the result, as also have the manner and material of the suspension of the coil.



Ayrton and Mather's D'Arsonval Galvanometer.

These points have been carefully studied by Prof. Ayrton and Mr. Mather, both mathematically and experimentally, and their results have led to the designing of the instrument shown and described by them at the last meeting of the Physical Society, and illustrated herewith.

The permanent magnet, of circular form, with a narrow gap between its poles, rests directly on the base, and the plate which holds it in place also carries a circular level by means of which the instrument may be rapidly set up.

Semi-Transparent Scale.

The narrow coil, which has a cross-section in the form of two circles having a common tangent at right angles to the mirror, is enclosed in a silver tube. The shape of the coil was arrived at from theoretical considerations by Mr. Mather (*Proc.* Phys. Soc., vol. x., page 376), as giving the greatest deflecting moment per unit moment of inertia. In this respect the coil is twice as efficient as the older

form. The silver tube enables the coil to be suspended without straining it, and serves the double purpose of damping the motions of the coil by the Foucault currents which pass up and down it when in motion, and of protecting the coil so as to enable it to be clamped without damage. The coil-tube is hung in an outer tube of brass by means of a flat strip of phosphor bronze, and the current is taken out of the coil through an insulated pin in the silver tube by a spiral of flat phosphor bronze, the lower end of which is connected to a contact screw in the outer brass tube. This mode of suspension ensures the centre of gravity of the coil being always directly under the point of suspension, and obviates the sudden tilting which almost always occurred in the older instruments at some position of the coil. The use of phosphor bronze gives us a very elastic suspension, and the flat form provides tensile strength and radiating surface with small torsional rigidity.

The mirror is attached to the coil-tube by means of a light, three-armed metal clip, and moves in a mirror-box provided with an aperture, closed by a sliding glass plate. To clamp the coil and enable the instrument to be carried about, a plug attached to a flat spring presses on the coil-tube through a hole in the outer tube. When the instrument is in use the plug is drawn out and slides down a slot in the spring. This is a great improvement on the old form, in which, after letting down the coil and thus altering the adjustments, the coil was usually wedged in place with bits of paper.

The outer tube, with its mirror-box and adjusting head, fits a socket between the poles of the permanent magnet, and the act of sliding it in place makes the connections. Thus several coils may be kept ready suspended of various resistances, and any one slipped in place in a few seconds. Thus the advantages of portability, dead beatness, quickness, and sensibility are combined. As regard sensitiveness, the improvement over the old form is apparent, being, for the same resistance and period, as great as that of a Thomson reflecting galvanometer.

The instruments are being made by Mr. Paul, of 44, Hatton-garden, E.C.

COMPANIES' MEETINGS.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY, LIMITED.

An extraordinary general meeting of the Western Counties and South Wales Telephone Company, Limited, was held on Tuesday afternoon, for the purpose of agreeing to the amalgamation of the Company with the National Telephone Company. Mr. Charles Nash presided over a large attendance.

The **Chairman** moved the adoption of a resolution approving of the provisional agreement entered into for the transfer of the Company to the National Telephone Company, and, in doing so, said five of the six English telephone companies had been amalgamated, and he thought it would be a very undesirable thing that their Company—the sixth—should stand altogether aloof. One special reason of not standing aloof was the matter of treating with the Post Office authorities. They were probably on the eve of a revolution in telephone work, and it would be very desirable to have the advantage of a united front. The Directors had made the best terms they could with the National Telephone Company, and they thought the shareholders would be right in confirming the provisional arrangement that had been made. Under the agreement the shareholders would receive a dividend of £1. 13s. 4d. per cent. on their shares; that was more than they had received up to the present time, and it was certainly more than they could expect to earn if arrangements were made to go on independently.

Mr. Mark Whitwill seconded the motion.

Mr. George White said at the last meeting the only apparently plausible excuse put forward for selling the undertaking to the National Telephone Company was want of funds. A protest against the sale was made by members of the Bristol Stock Exchange. A letter, dated June 8th, signed by the secretary to the Company (Mr. H. F. Lewis), was addressed to the memorialists through his (Mr. White's) firm, in which it was stated that if the signatories would give a firm offer to raise a sum of £100,000 upon second preference shares at such a rate of interest as would not exceed the earning power of the Company, the Directors would submit the proposal to the National Telephone Company, and suggest that the latter should give to the Western Company an option of either accepting the terms of amalgamation or of raising additional capital for the continuation of the Company as a separate undertaking. He replied in a letter, in which he said one of the first considerations of the arrangement would be a reconstitution of the Board of Directors, and if the Directors would approach the subject on this basis a committee would be formed by members of the exchange to formulate a scheme for submission to the shareholders. The Directors, instead of accepting this offer, said if they were going to sell to the National Company they must settle quickly, and immediately got out the notice for that meeting. He did not think that was a proper way of treating this question, and it was not creditable to Directors representing Bristol shareholders. Seeing that they were so far right in regard to their capital requirements, there was no necessity to hand themselves bodily over to the National Company. They should have taken time and have been prepared to discuss the matter with the Stock Exchange, and to place an alternative proposal before the shareholders. On the 17th of June he received a letter stating that his communication had been forwarded to the National Company, whose reply was that it did not contain any offer on which a new negotiation could be effected. The Directors, he went on to say, had shifted their ground, and now stated that the reason for amalgamation was the necessity for joint action in the face of the Bill which would be passed this session enabling the Post Office to purchase the trunk lines of the telephone companies. But the National Company were sufficiently interested in the Western Company to assist them in their negotiations with the Government without amalgamation. If a dividend of 1¾ per cent. was all they were to expect it was time some other gentlemen undertook the management of the undertaking. If the Directors insisted on rushing this matter through ultimately the shareholders would have to go to the courts to secure their rights. Had the Board asked anybody else to buy the undertaking?

The **Chairman**: No; we have been from the very first a child of the National, and certainly we have not gone elsewhere; it is utterly hopeless to think of such a thing.

Mr. White: You have tied yourselves hand and foot to the National. There was a chance of selling the undertaking in another quarter and on better terms. He proposed as an amendment that the meeting be adjourned for three weeks to enable the Directors to further consider the position.

Mr. MacKnight (Liverpool) seconded the amendment, and urged that the National Company had not been firmly met by the Board. The prospects of the Company were most encouraging.

Mr. E. W. S. Stroud supported the amendment.

Mr. Inskip (solicitor to the Company) pointed out that the National Company had power to control all the negotiations the Company entered into.

Mr. Cory (Cardiff) said from the speeches that had been made it appeared some people thought that the Directors were a lot of "duffers." But they were all successful men of business. He contended that the Directors had in this matter acted in the best interests of the shareholders, and they had not tied themselves to the National Company. If they relied on the Bristol Stock Exchange they would have lost their most valuable connection, and got worse terms than the present.

The **Chairman** said if the motion were rejected the position of the shareholders might be very much worse.

The amendment was put to the meeting, and only six hands were held up against it.

Mr. Inskip said a poll must be taken.

Mr. White protested against a poll being taken on a question of adjournment, and said if it were persisted in the resolutions would be illegal, and the question would be tested in the courts.

The Directors having consulted together,

The **Chairman** said he thought they must take a poll. A very large number of shareholders had expressed their approval of the course that the Directors had taken.

Mr. Inskip hinted at the possibility of a conference with the Directors.

Mr. White said he had intended to ask the Directors to receive a certain number of shareholders during the three weeks to discuss the various questions.

The Directors retired for consultation, and on their return,

Mr. Inskip said it had been decided to take a poll at once on the motion for the adjournment.

Mr. White said he should test the matter in the courts, and asked the shareholders who agreed with him as to the desirability of an adjournment to leave the room.

Several rose to their feet.

Mr. Inskip observed that as far as the Directors could ascertain the number of shares represent by the shareholders present was 3,200.

Mr. White advised the shareholders to leave.

All the shareholders, with the exception of three, left the room.

A poll was taken, and it was announced by **Mr. Inskip** that the motion for adjournment was lost. The votes against it including proxies, represented 87,285 shares. The gentlemen who had withdrawn represented 3,375 shares. The National Telephone Company, who held 159,900 shares, had not voted.

The resolution was then adopted, as also were resolutions for the voluntary winding up of the Company and the appointment of Mr. T. A. Welton, Moorgate-street, London, as liquidator.

A vote of thanks to the Chairman closed the proceedings.

West African Telegraph Company.—A balance dividend of 5s. per share is proposed by the Directors, making a total payment of 4 per cent. for the year ended December last.

NEW COMPANIES REGISTERED.

Electric Clock Company, Limited.—Registered by Steadman, Van Praagh, and Sims, 23, Old Broad-street, E.C., with a capital of £1,200 in £1 shares. Object: the promotion and subsidising of companies, and the general business of a financial agency. There shall not be less than two nor more than seven directors. The first are to be elected by the signatories to the memorandum of association. Qualification, £50. Remuneration to be determined by the Company in general meeting.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting 17 per cent. payable to the London Platino-Brazilian Company, were £2,578.

St. James's and Pall Mall.—A private meeting of the holders of founders' shares in the St. James's and Pall Mall Electric Light Company, Limited, convened without consultation with the Directors, was held at Winchester House yesterday.

City and South London Railway.—The receipts for the week ending June 19 were £771, against £721 for the same period of last year, or an increase of £50. The total receipts to date from January 1, 1892, show an increase of £1,207 as compared with last year.

West Coast of America Telegraph.—The accounts for the year 1891 show, after deducting debenture interest and other charges, a surplus balance of £1,413 to be carried forward. It is stated that a land line is already in course of construction, which will connect the Company's system with those of the Western and Brazilian, the Brazilian Submarine, and the Eastern Telegraph Companies.

National Telephone.—The Directors, at their meeting held on Wednesday, resolved, subject to final audit, to recommend the following dividends for the last half-year—viz., at the rate of 6 per cent. per annum, less income tax, on the amounts paid upon the first and second preference shares; and at the rate of 7 per cent. per annum, less income tax, on the amount paid up on the ordinary shares, making, with the interim dividend already paid, 6 per cent. for the year ended April 30. The transfer-books of the Company will be closed from July 1 to July 14, both days inclusive, and the dividend warrants will be posted on the latter date.

New Firm.—Messrs. Bergtheil and Young have started as electrical engineers and contractors at 13, Walbrook, E.C. Mr. Arthur Bergtheil has been the late manager of the Wenham Company's electrical department, and has carried out a large installation at Madame Patti's castle and theatre in Wales, also Holland House, Kensington, and he is also the designer of the windmill plant at Messrs. Carwardine's mills in City-road, upon which we have already commented. Mr. H. Wilson Young is late of Messrs. Clarke, Chapman, and Co., Gateshead-on-Tyne, and was for some considerable time abroad for that firm in connection with Parsons high-speed turbo-generators supplied to the Italian Government.

PROVISIONAL PATENTS, 1892.

JUNE 13.

11050. **Improvements connected with tubular electric conductors.** David Cook and Ernest Payne, 39, Victoria-street, London.

11067. **Improvements in and connected with joining the ends of telegraph and telephone and other wires, and in machines for preparing the said ends of the wires.** Weston Alcock Perry, 128, Colmore-row, Birmingham.

11071. **Improvements in electrical apparatus for scoring in billiards or other games, applicable also for showing the number of revolutions of marine and other engines, and for other purposes.** William Smetham, 11, Victoria-street, London.

11085. **Improvements in electrical indicators.** Woodhouse and Rawson United, Limited, 88, Queen Victoria-street, London. (Richard Varley, United States.)

11087. **Improvements in galvanic batteries.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Tito Rosati, Emilio Righetti, and Giulio O'Connell, Italy.)

11096. **Improvements in or relating to telegraphic instruments.** Arthur Cunningham Moll, 323, High Holborn, London.

11104. **Improvements in telephonic apparatus.** Hemming Hammarlund, 45, Southampton-buildings, Chancery-lane, London.

JUNE 14.

11119. **Improvements in electric switches.** Francis Broadnax, 15, Water-street, Liverpool. (Complete specification.)

11126. **An improved element by the aid of which a current of electricity may be generated.** John Paterson, 9, Grosvenor-street, Colne, Lancashire.

11147. **Improvements in secondary or storage batteries.** Henry Herbert Lloyd, 323, High Holborn, London. (Complete specification.)

11154. **Improvements in the method of welding metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles L. Coffin, United States.) (Complete specification.)

11181. **An improved construction of electric alarm clock.** William Petchey, 9, Warwick-court, Gray's-inn, London.

11192. **Improvements in and relating to the driving of dynamo-electric machines, and in apparatus therefor.** Thomas Reid, 46, Lincoln's-inn-fields, London.

JUNE 15.

11194. **Improvements in indicating apparatus for high-tension circuits.** Bernard Mervyn Drake and John Marshall Gorham, 66, Victoria-street, London.

JUNE 16.

11277. **Improvements in electric current meters.** George A. Goodwin and Herbert Foster, 2, Victoria-mansions, Victoria-street, Westminster, London.

11302. **Improvements in electrical measuring instruments.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 16, Red Lion-street, Clerkenwell, London.

11316. **Improvements in or connected with electric alarums.** Gerhard Wilhelm van Vianen, 33, Chancery-lane, London. (Complete specification.)

11320. **Improvements in telephonic apparatus.** Cæsar Vogt, 38, Chancery-lane, London. (Complete specification.)

JUNE 17.

11344. **Improvements in casing for cables and wires.** Frederick Baumgart Nicholson, 9, St. Petersburg-place, Bayswater, London.

11353. **Improvements in electrical alarum clocks.** Daniel James Mullarky, Sunbridge-chambers, Bradford. (Complete specification.)

11382. **An improved process for manufacturing compound and elementary bodies or chemical products by means of electricity, and apparatus therefor.** Herrman Niewerth, 4, South-street, Finsbury, London.

11393. **Improvements in or relating to electric railways.** Frank Wynne, 46, Lincoln's-inn-fields, London.

11403. **Improvements in electric generators and motors.** Walter Thomas Goolden and Llewelyn Birchall Atkinson, 1, Queen Victoria-street, London. (Complete specification.)

JUNE 18.

11424. **Improvements in automatic telephone and other electric exchanges.** George Cecil Dymond, 6, Lord-street, Liverpool. (Almon B. Strowger, United States.) (Complete specification.)

11426. **Improvements in or relating to indicating electric switches and current reversers.** George Cecil Dymond, 6, Lord-street, Liverpool. (Almon B. Strowger and Walter S. Strowger, United States.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1891.

8798. **Electrical signalling.** Hanusse and Borrel.

10434. **Electric meters.** Singer.

12018. **Electrical gear for steering ships, etc.** Wilson.

12529. **Distributing electric currents.** Edmunds.

12605. **Electric batteries.** Lake. (Lacombe and Co.)

14517. **Microphones.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

15337. **Electrical condensers.** Muirhead.

1892.

2488. **Electric lighting.** Trippe.

7253. **Generating electricity.** Duffy.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	$3\frac{1}{4}$
— Pref.	—	$2\frac{1}{4}$
India Rubber, Gutta Percha & Telegraph Co.	10	$20\frac{1}{2}$
House-to-House	5	$5\frac{5}{8}$
Metropolitan Electric Supply	—	7
London Electric Supply	5	$\frac{7}{8}$
Swan United	$3\frac{1}{2}$	$4\frac{1}{8}$
St. James'	—	$8\frac{1}{2}$
National Telephone	5	$4\frac{7}{8}$
Electric Construction	10	$6\frac{1}{4}$
Westminster Electric	—	$6\frac{9}{16}$
Liverpool Electric Supply	5	$5\frac{1}{8}$
	3	$3\frac{1}{2}$